AGRICULTURAL ENGINEERING

APRIL • 1953

In this Issue . . .

L-Shaped Fence Staple Exceeds Holding Power of V-Shaped Product

Agricultural Engineers Study Pressures on Grain Bin Walls and Floors

Absorption of Solar Radiation by the Hair of Cattle

Land Drainage — An Important Tool to Increase Crop Production

Sprinkler versus Gravity Irrigation —A Basis for Selection

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Pivotal Action

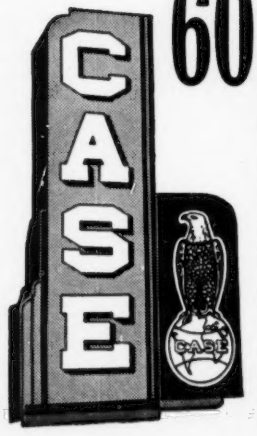
Cuts Full Slice on Curves

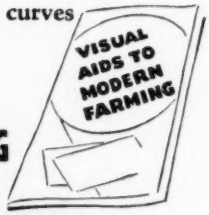
This revolutionary plow now makes contour plowing practical and is ideal for terrace building. The front bottom cuts neither too narrow nor too wide. Scientifically-located pivot point keeps all bottoms of Case Breakaway-Contour Plows cutting true-width furrows on contour curves. Takes but a minute to hook up to Eagle Hitch of Case Tractor, right from the seat and depth can be adjusted from seat. Constant Hydraulic Control lifts, effortlessly. Pivotal Action eliminates side draft, works as beautifully on curves as on straightaway.

Breaks away, too! Stumps and stones that would damage fixed plows simply cause the Case Mounted Breakaway-Contour Plow to uncouple from its foreframe. Driver recouples in a jiffy just by backing tractor. He lifts plow over obstruction with Constant Hydraulic Control and goes on plowing—little time lost!

Case Pivotal Action Plows are conservation plows. Not only aiding conservation of soil and water, they help save human energy and time, promoting ever-greater production per man, per hour, per acre, and per machine.

For decades Case has spearheaded the war against waste by providing farmers with implements ideally suited to conservation practices. Now, with its remarkable Eagle Hitch and implements far advanced in concept and function, Case continues to create weapons for the fight.





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performance

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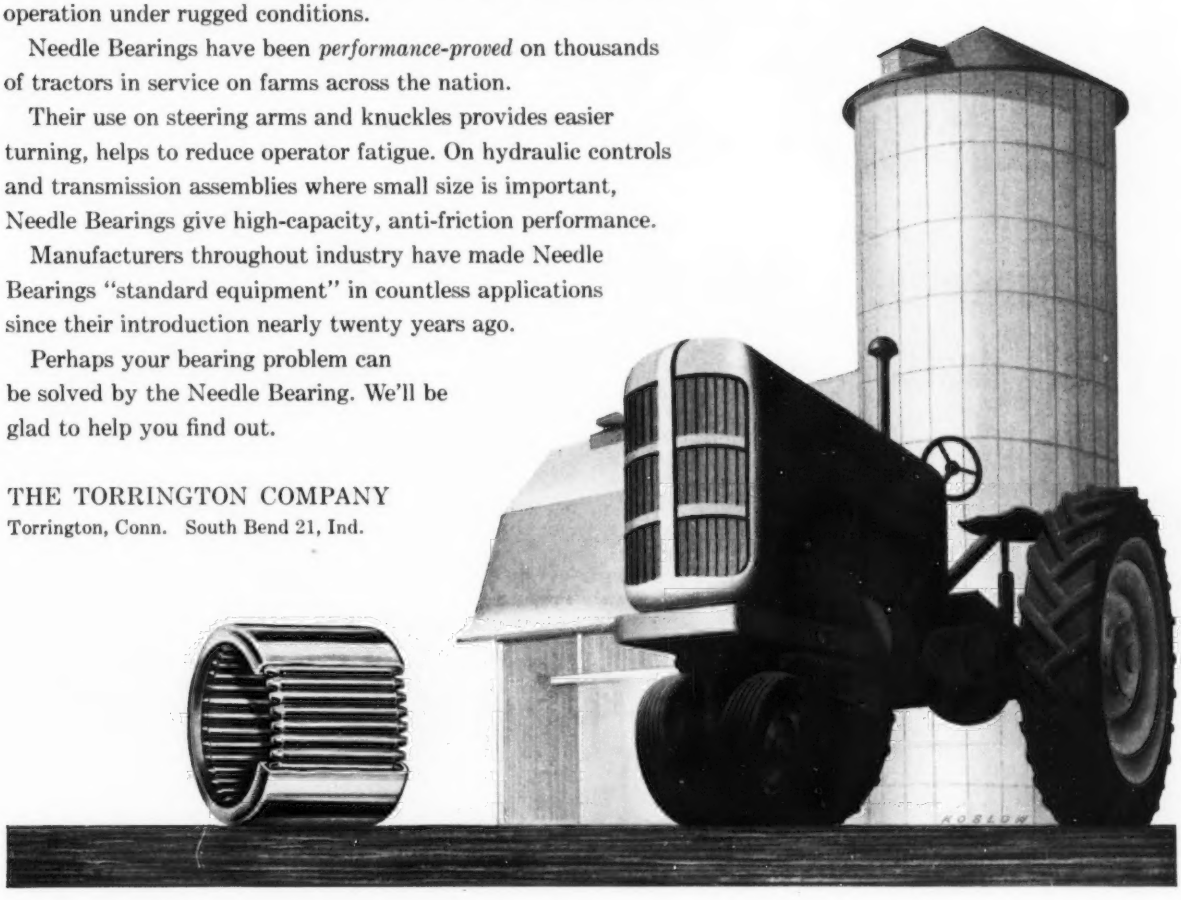

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Maurice Nissley (left) of Manheim, Pennsylvania, explains operation of his potato duster to Texaco Man Clyde Mumper of Garber Oil Co., Mt. Joy. Mr. Nissley uses Havoline Motor Oil in all his engines because it meets Heavy Duty requirements, is ideal for gasoline or Diesel motors and equipment using L-P gas as fuel. It practically eliminates wear.

This homemade potato duster covers 12 rows at a time

Rain or shine, Maurice Nissley of Manheim, Pennsylvania, can dust his 125 acres of potatoes with ease, thanks to the novel duster he put together in his workshop.

The vehicle is an old Reo truck. A 24-horsepower engine operates the duster fan. Hydraulic power is used to raise and lower and pull back and forth the duster booms. There are six dusters on each boom, enabling Mr. Nissley to dust twelve rows at a time. The duster is equipped with tractor tires so he can get in and out of the field, even in wet weather.

Mr. Nissley has found that *it pays to farm with Texaco Products.*

In Texas where it gets zzz-HOT! Marfak lubricant is the choice of keen ranchers and farmers because it sticks to bearings better, doesn't melt down and run out, dry out, cake up, or jar off. Prominent Rancher William Palm of Sealy, Texas, pumps in the Marfak as Texaco Man Edmond Luhn, driver for Consignee R. R. Hillebrand, looks on.

"Experience is the best teacher": says Harvey Febock (right), keen farmer of London, Wis.: "Good oil and grease more than pay for themselves. We ran our combine eight years on Havoline Oil and Marfak lubricant without a breakdown. A neighbor was using ordinary oil and grease and had constant trouble. It pays to use the finest lubricants." Interested listener is Texaco Zone Manager Ken Barnekow (left) of Madison, Wis.

Friendly Service — that's what farmers and ranchers want and get from Texaco Men from coast to coast. Texaco Man C. H. Davis, driver for Consignee K. B. Teeter is greeted at 2,000-acre Hoover Ranch, Medford, Oregon, by Hoover children as he prepares to deliver Fire-Chief, the gasoline with superior *"Fire-Power"* for low-cost operation. The Hoovers say Texaco Service is "unbeatable."

The Hoovers have also found that the Texaco Dealer in town is *the best friend their cars ever had.* Raymond Brothers, in Medford, service not only the Hoovers' cars but the Arabian Horse shown, "tanking up" with water from the hose.

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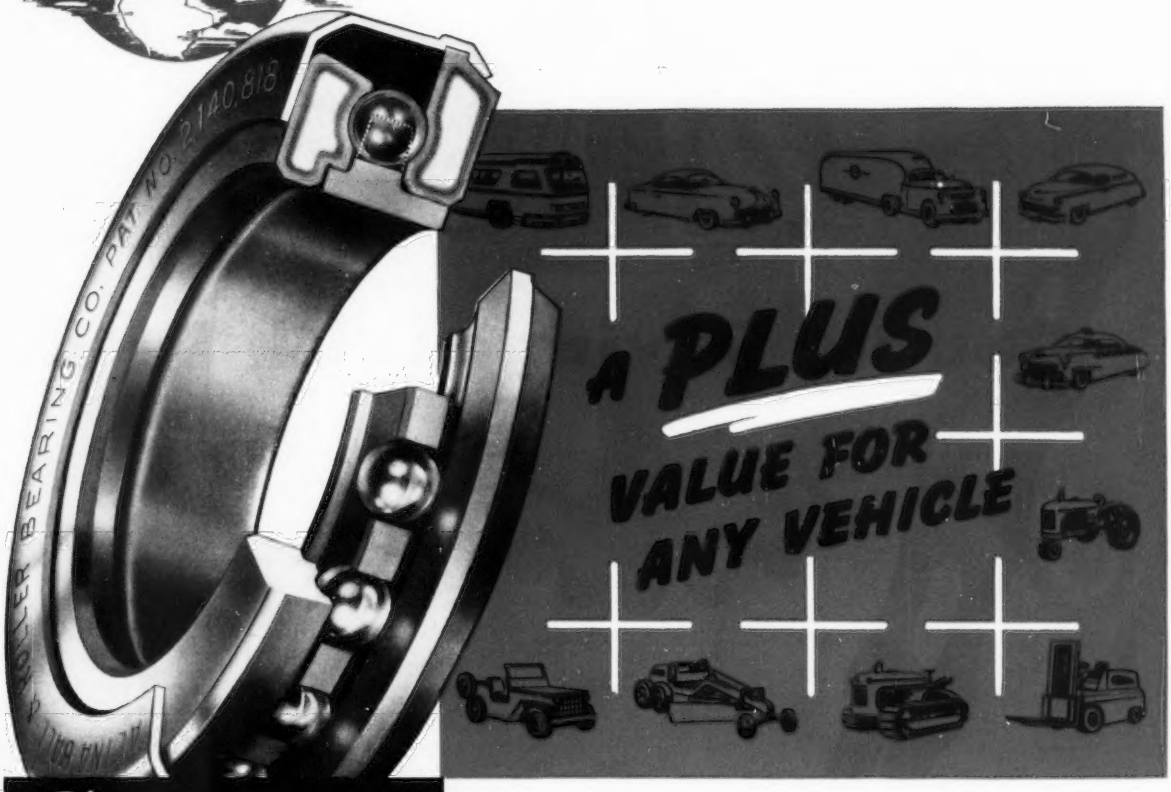

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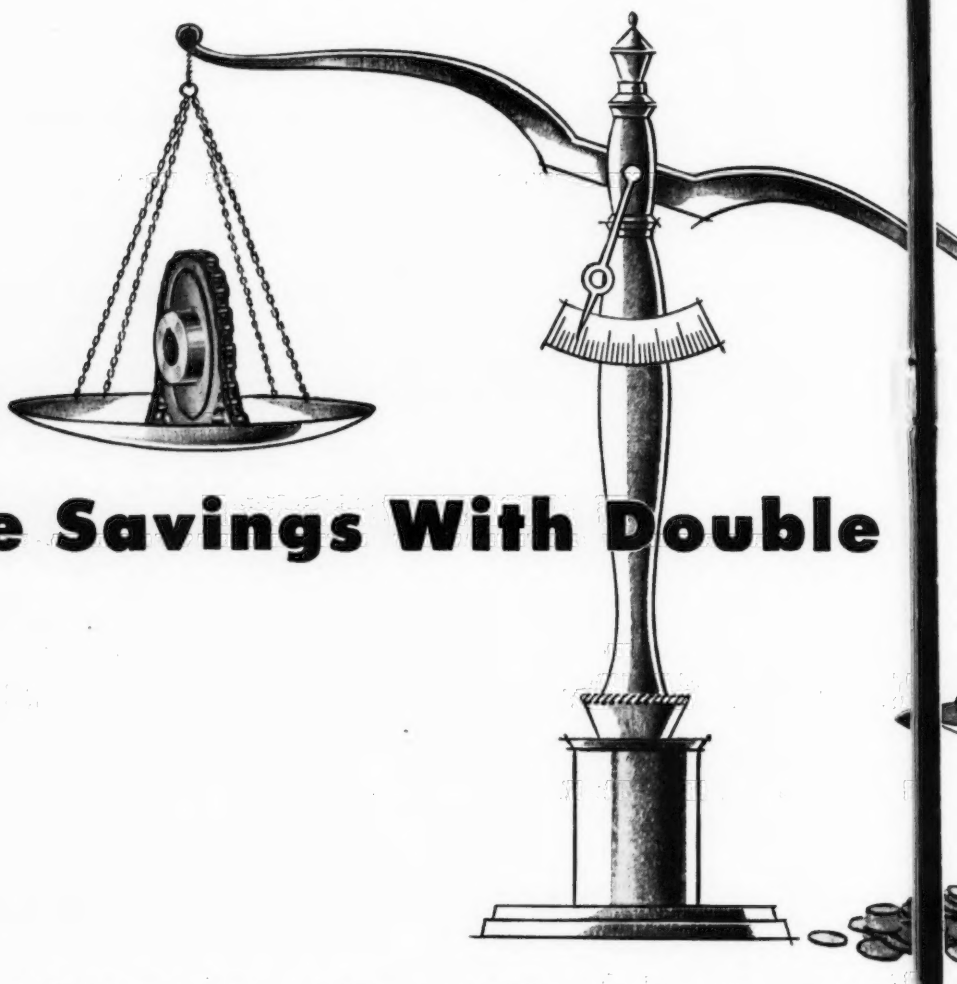

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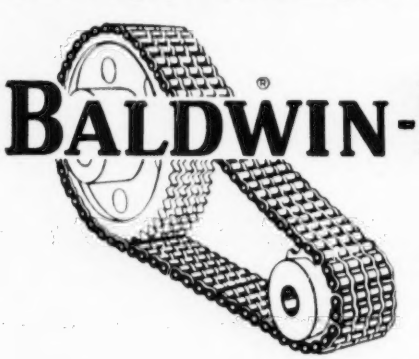

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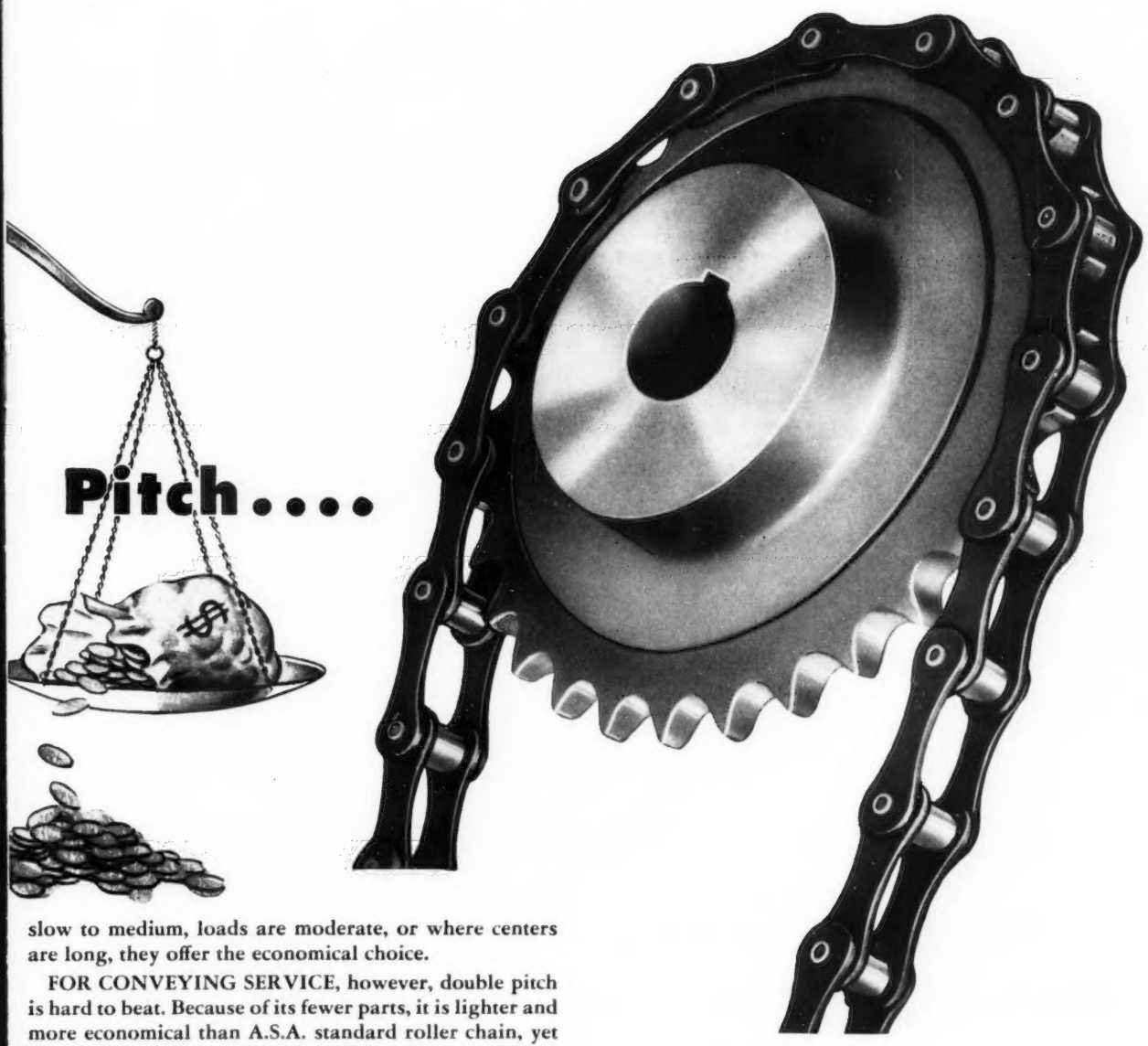

slow to medium, loads are moderate, or where centers are long, they offer the economical choice.

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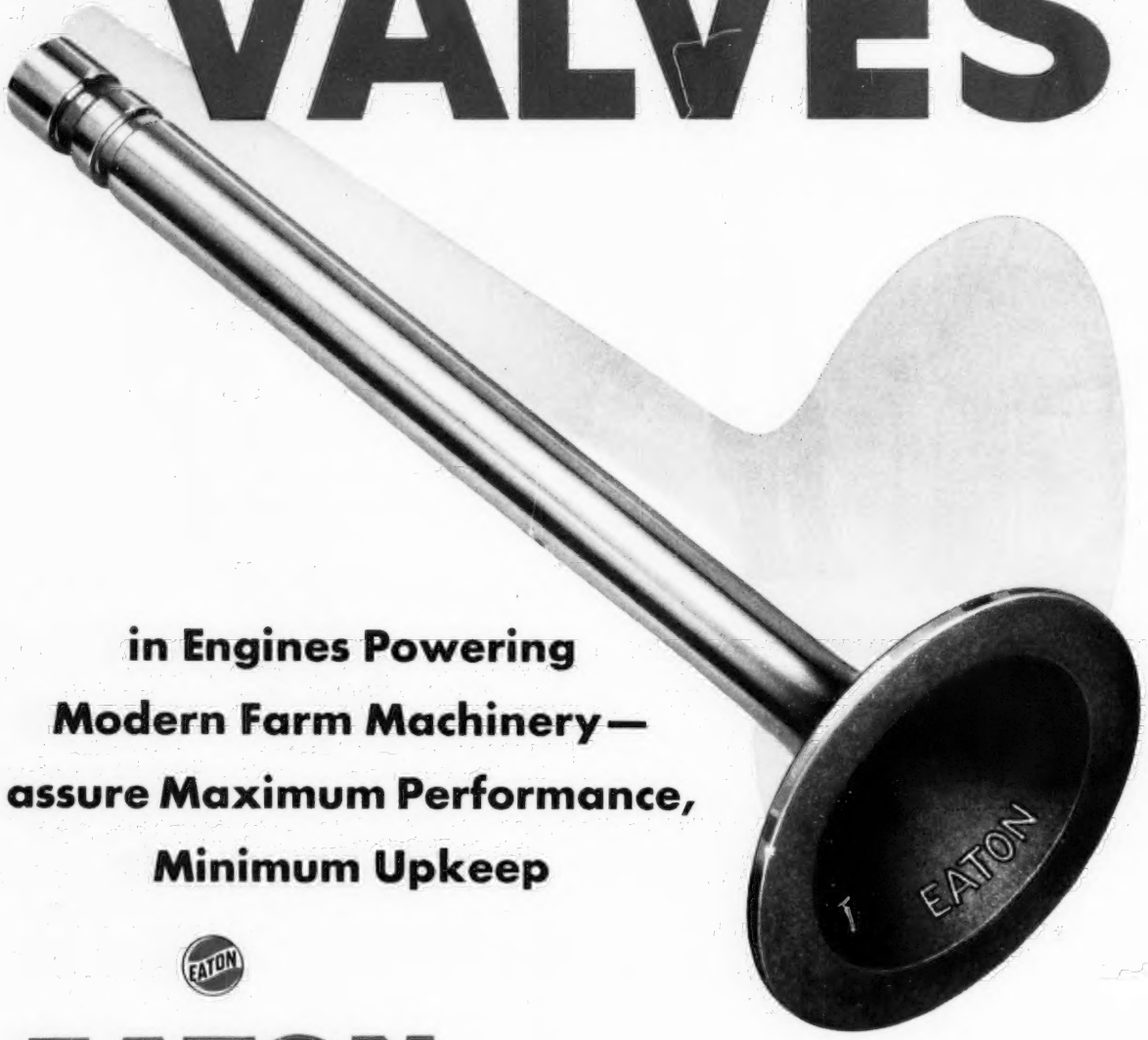

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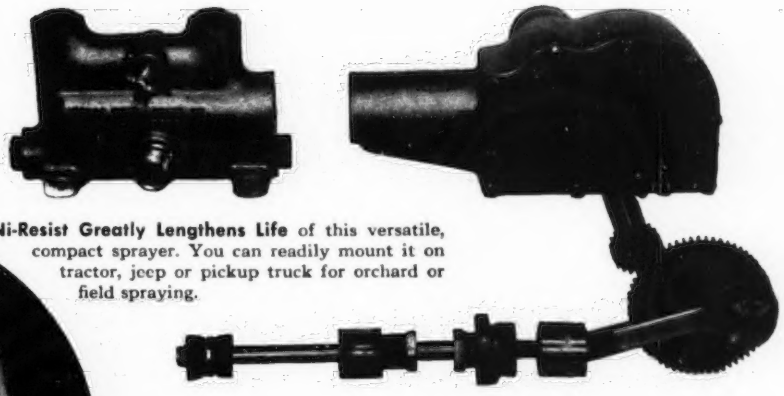

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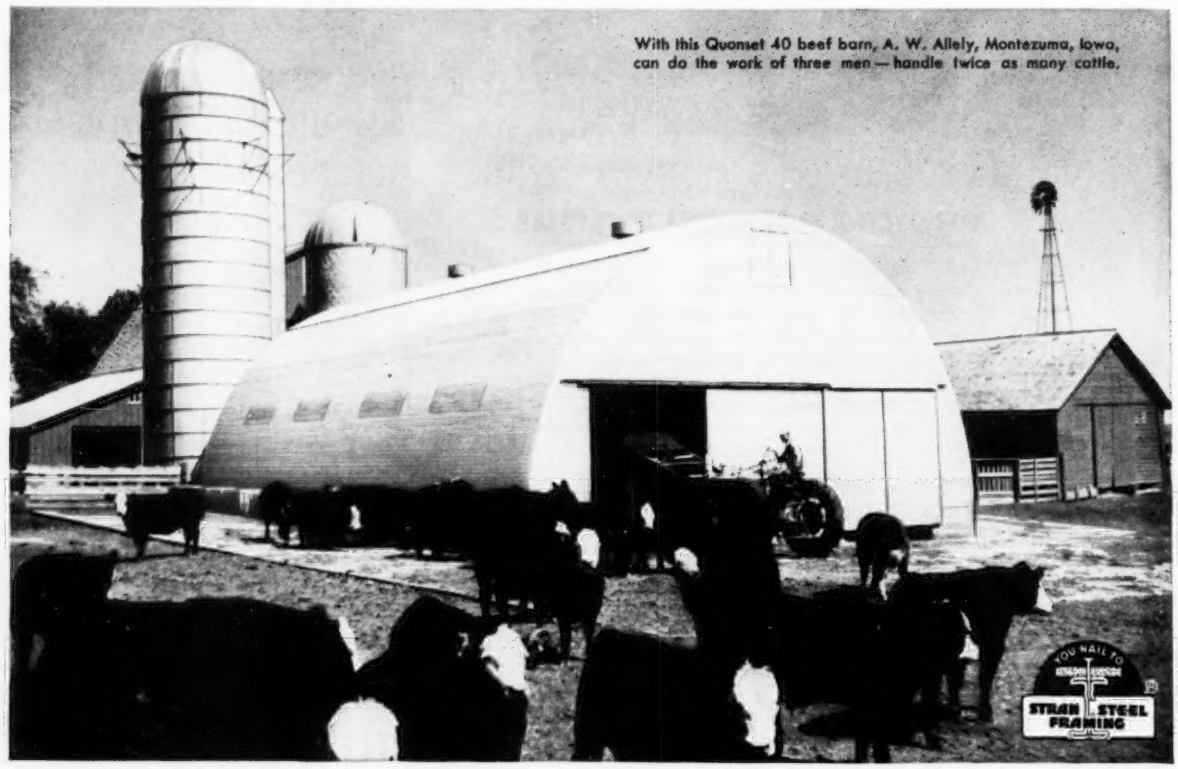
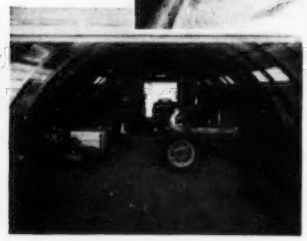


With this Quonset 40 beef barn, A. W. Allely, Montezuma, Iowa, can do the work of three men — handle twice as many cattle.

100,000 American farms are better producers . . . thanks to Quonset Quality-Construction

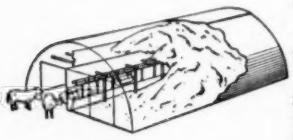


Quonset drying and storage permits earlier, cleaner harvest, better market control for W. R. Mitchell, Grundy Center, Ia.

"My farm machinery is easier to service," says Endren P. Johnson, Huxley, Iowa, of his Quonset.

Good-looking, durable and easy to maintain. That's the Quonset . . . all-purpose farm production tool.

"Now, with a Quonset 40 x 60, I can do the work that used to take three men," says A. W. Allely, who handles 60 cows and their calves, 20 brood sows and 120 pigs a year on his Montezuma, Iowa, farm. Before he built his Quonset, the same operation required two hired men in addition to himself.



At feeding time, Mr. Allely simply topples chopped hay into the feeding rack (see diagram at left).

Silage is easily fed from an adjoining silo with an overhead carrier which runs the full length of the feed rack.

The Allely Quonset saves cleaning time, because it is post-free. With use of a power fork chore time is cut to the bone. Clear-span Quonset construction also makes it easier to blow hay into the building.

Quonset farm service buildings are designed to work as production tools . . . to cut costs, cut chore time, and make money for you. Find out today how you can have all-steel quality construction on your farmstead.

Easily Financed with the Quonset Purchase Plan. It's simple to finance your barn, hog house or machinery shed with the new Quonset Purchase Plan. Your dealer will gladly show you how.

Consult your authorized Quonset Dealer, a specialist in farm service buildings, or write us direct for complete information on the Quonset best suited to your operation.

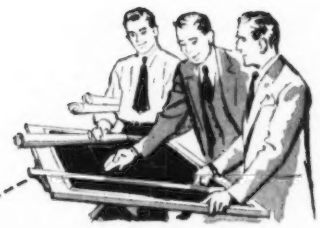
Farm for the Future...with Quonset®

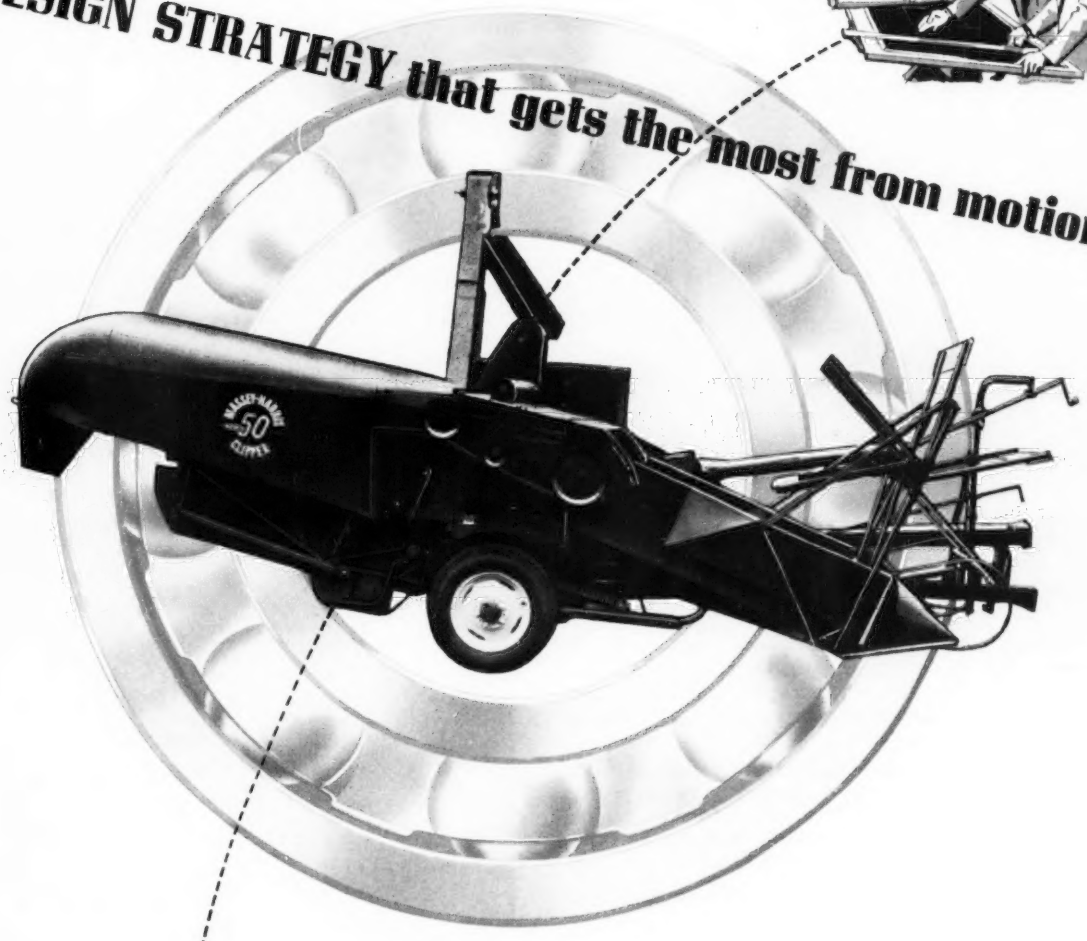
GREAT LAKES STEEL CORPORATION

Stran-Steel Division Ecorse, Detroit 29, Mich.

NATIONAL STEEL CORPORATION

DESIGN STRATEGY that gets the most from motion

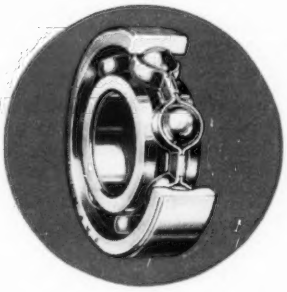




In designing the Clipper "50" Combines, Massey-Harris went "all out" to provide greater value, separating capacity, threshing ability and operation ease. Like other leading farm equipment manufacturers, Massey-Harris makes good use of Fafnir Ball Bearings to get the most from motion...the most power with the least wear and tear and trouble. Ball bearing applications include cylinder shaft, main drive idler, take-off, gear box shafts and sickle drive.

More and more farm machinery is being equipped with Fafnir Ball Bearings... standard radial types, types with seals and shields, prelubricated types, Pillow Blocks and Flange Cartridges featuring the Fafnir Wide Inner Ring Bearing with Self-Locking Collar and Mechani-Seals, and the famous Fafnir Flangettes.

Good quality and a wide range of types and sizes aren't the only reasons for the ever-growing popularity of Fafnir Bearings. Equally important is the Fafnir "attitude and aptitude"... a way of looking at bearing problems from the designer's viewpoint, an aptitude for providing the precise bearing to fit the need. Maybe these Fafnir attributes can help you. The Fafnir Bearing Company, New Britain, Conn.



Fafnir Radial Ball Bearings take thrust or radial loads or both . . . available with various arrangements of seals or shields to meet specific requirements. Snap rings for axial location are available also.

FAFNIR
BALL BEARINGS
MOST COMPLETE LINE IN AMERICA

Why the leaders prefer

PUROLATOR
FULL-FLOW
MICRONIC FILTERS

✓ **Full-flow rates within practical filter dimensions:** The famous "accordion-pleated" Micronic* filter element has up to ten times more filtering area than old-style filters—gives high flow rates in a minimum of space.

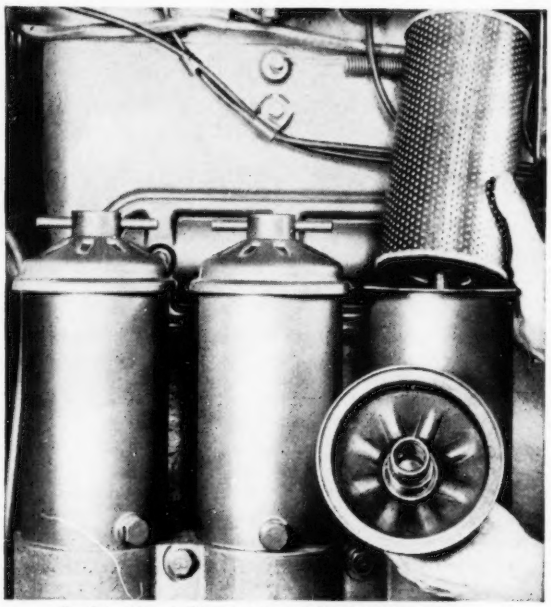
✓ **Ultra-micronic filtration:** High flow rates are, of course, meaningless unless effective filtration is maintained, too. Electron micrographs prove that the Purolator* Micronic filter stops particles down to *submicrons*—.0000039 in.!

✓ **Maximum dirt storage capacity:** The pleated design of the Micronic filter element provides many times more dirt storage space than old-style filters. This important advantage means uniform, efficient performance and a lengthy service life.

✓ **Minimum pressure drop:** The Purolator Micronic filter element introduces a remarkably small pressure drop in the lubricating system . . . permitting pumps of practical size and simple type.

✓ **Will not remove or absorb additives:** With Purolator Micronic filtration, you keep *all* the oil quality you pay for. The Micronic filter element will not strip additives . . . an important advantage with modern HD and heat-resistant oils.

*Reg. U. S. Pat. Off.



Purolator Micronic Filters in a typical Diesel full-flow installation. Although the Purolator Micronic filter elements measure only 4½ in. by 9 in., each one filters 9 gallons of oil per minute, giving a total of 27 g.p.m. for the complete filter unit.

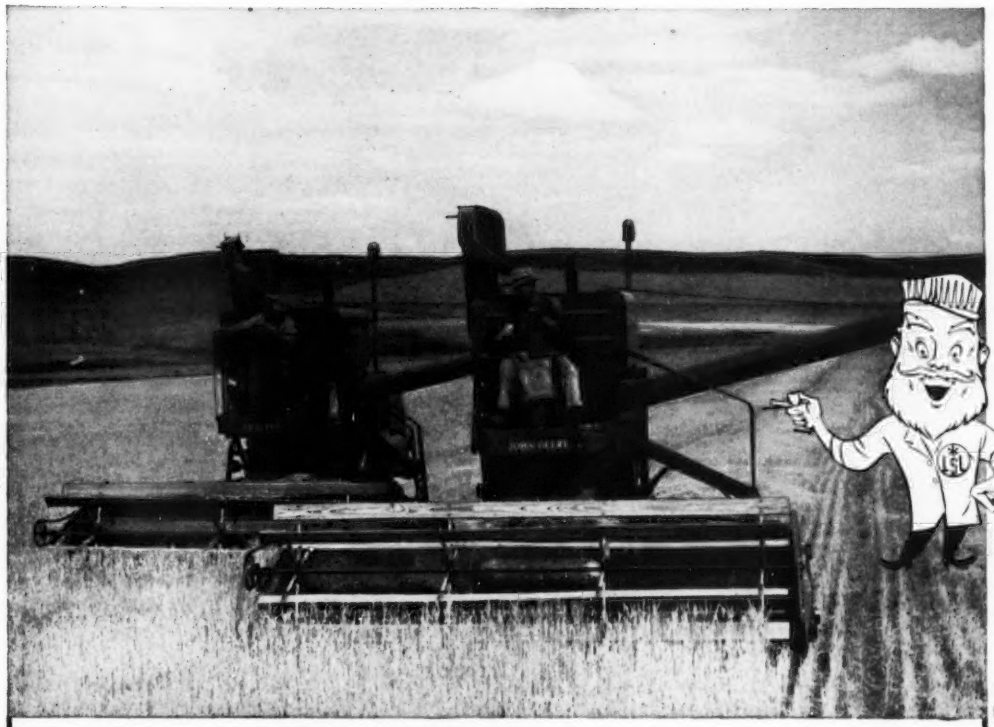
THE advantages of Purolator Full-Flow Micronic filtration—wherein *all* the oil is filtered *each time* it passes through the engine—have been dramatically demonstrated during the past few years. In some instances engine life has been increased by thousands of hours, bearing and ring wear has been reduced to almost imperceptible minimums, and engines have been made to operate efficiently where air-borne abrasives formerly destroyed them in a matter of hours. One after the other, leading makers of Diesel and gasoline engines and vehicles are adopting full-flow lubrication . . . and standardizing on Purolator Full-Flow Micronic filters. In some fields, manufacturers are finding that full-flow lubrication is becoming a necessary feature to maintain a competitive sales position.

Time and again, in impartial tests conducted by vehicle and engine manufacturers themselves, Purolator Micronic filters have been proved best on all counts . . . fineness of filtration, long service life, ease of servicing.

Our Engineering Department will gladly co-operate in helping you prove—*in your own way, on your own equipment*—that there is no finer filter made than Purolator. Simply write, describing your equipment and filter requirements.

PUROLATOR PRODUCTS, INC.
Rahway, New Jersey, and Toronto, Ontario, Canada
Factory Branch Offices: Chicago, Detroit, Los Angeles

PUROLATOR
MICRONIC OIL FILTER
"FIRST IN THE FIELD OF FILTERING"



Above: Deere & Co. self-propelled combines.

These and other manufacturers of hundreds of thousands of fine farm machines use Morse Power Transmission Products:

Deere & Company	The Massey-Harris Company	Allis-Chalmers Manufacturing Company
J. I. Case Company	International Harvester Company	Massey-Harris, Ltd.
The Oliver Corporation	Minneapolis-Moline Company	Cockshutt Farm Equipment, Limited
	New Holland Machine Company	

M=PT; Morse *means* Power Transmission

Why demanding agricultural engineers specify Morse Power Transmission Products

*Engineering Service; Long Service Life; Quality—which you get in unusual degree when you buy Morse Power Transmission Products.

From the design phase of your machinery through its long life in your customers' hands, Morse Power Transmission Products can help you to notable product improvement.

For instance, Morse Roller Chains, Morse Double-Pitch Roller Chains, Morse Flexible Couplings, and Morse Sprockets are designed and built to withstand the heat, cold, dust, and water to which your machines are subjected year after year.

They help you give customers more assurance against breakdown, more protection against the cost and annoyance of extra maintenance and parts replacement.

Morse products give you proved design advantages such as the weight, space, and cost savings of Morse Double-Pitch Roller Chains; the flexibility, efficiency, and compactness of Morse Roller Chains; the compactness of Morflex Flexible Couplings, which need no lubrication.

And, of course, Morse products enable you to meet the strictest cost and quality standards. Let us give you specific information on the Morse products in which you're interested.

MORSE
MECHANICAL
POWER TRANSMISSION
PRODUCTS

MORSE CHAIN COMPANY
Dept. 450
7601 Central Avenue • Detroit 10, Michigan

ALLIS-CHALMERS FORAGE HARVESTER

Today's big farm news is "factory-made" meat, milk, and eggs for our great city populations.

Our livestock farms are meeting lower prices and high labor costs by new assembly line methods. Tractor power and electricity are applied with the same efficiency as power in our modern factories. Bulk handling eliminates costly hand labor and permits one man to care for large herds.

And the trend has only begun. Soil conservation and grassland farming are giving new emphasis to forage crops, both as soil-builders and as low-cost feed. Grass and legume crops have become basic raw materials for these new food assembly lines.

The family farm continues to be one of America's most vital economic and social units — but today it has become a mechanized operation.

By necessity as well as choice, the successful farmer is highly selective in his farm machinery buying. Like the purchasing agent in any other factory, he demands advanced design and adequate capacity . . . plus reasonable price.

The popularity of machines such as the Allis-Chalmers Forage Harvester, Forage Blower, and the ROTO-BALER proves the soundness of this engineering approach.

ROTO-BALER is an Allis-Chalmers trademark.

ALLIS-CHALMERS
TRACTOR DIVISION • MILWAUKEE 1, U. S. A.

WHAT'S YOUR UNIVERSAL JOINT PROBLEM ?

If you're building implements like these, BLOOD BROTHERS offers great advantages

PRODUCT	BLOOD BROTHERS Universal Joints now used by leading implement manufacturers: Series	
Combines	3DR	L16S
Corn Pickers	1FR	3DR
Corn Snappers	1FR	3DR
Cotton Pickers	L6N	L16S
Diskers & Seeders	1FR	
Dusters	L6N	1FR
Elevators	K-1-C	1FR
Ensilage Blowers	K-1-C	L6N
Feed Grinders	L14N	35N
Forage Harvesters	35N	
Grain Binders	K-1-C	1FR
Hammer Mills	L14N	35N
Hay Balers	3DR	L16S
Hay Rakes	L10S L6N	1FR
Manure Spreaders	L10S	1FR
Mowers	L6N 1FR	L10S
Post Hole Diggers	K-1-C	1FR
Potato Diggers	1FR	3DR
Rotary Weeders	K-1-C	K2R
Shredders	L14N	35N
Shellers	1FR	3DR
Snow Plows	3DR L14N	35N
Sprayers	35N 1FR	3DR
Swathers	1FR	3DR
Tractors	K-1-C L6S	L6N
Wagon Unloaders	K-1-C K2R	1FR
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Need specific information? Blood Brothers will promptly supply details on these joints—or others suitable for construction equipment, trucks and buses, industrial machinery and marine applications. Our engineering staff—backed by 43 years' experience—will gladly assist you.

TORQUE CAPACITIES at Tractor Speeds of 550 rpm.

Series	Horsepower
K-1-C	3
K2R	3
L6S	4
L6N	5
L10S	5
1FR	10
L14S	11
3DR	15.7
L16S	19
L14N	30
35N	50

You can get joints alone or assembled with fixed or slip joint shafts... with or without integral safety shields, safety clutch, clamp yokes... or with the popular, salable quick-detachable yokes.

With Safety Clutch

1FR Series

PTO Slip Assembly

L6S Series

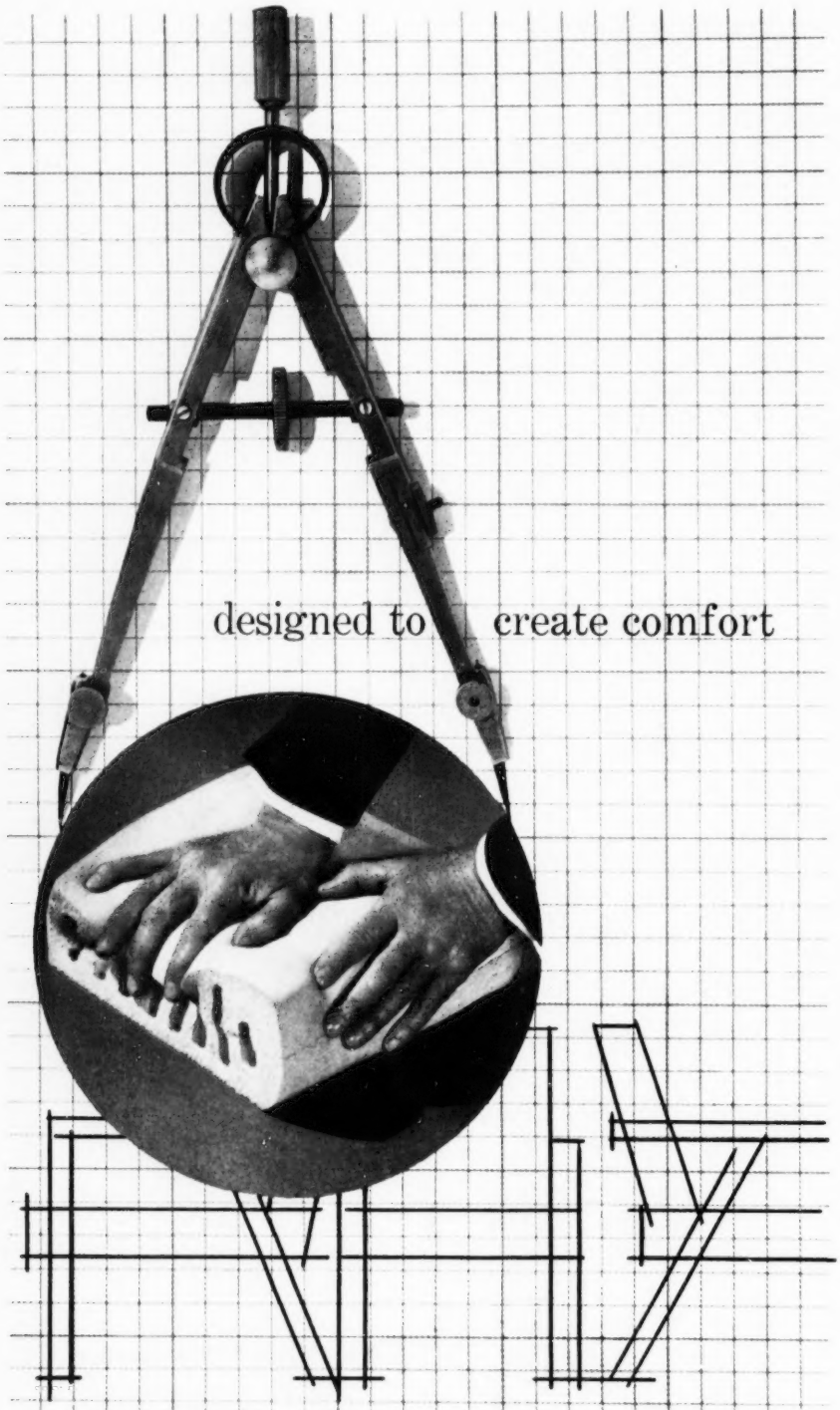
With Integral Safety Shields

Quick Detachable

BLOOD BROTHERS machine co. ALLEGAN, MICHIGAN

UNIVERSAL JOINTS AND DRIVE LINE ASSEMBLIES

A Division of Standard Steel Spring Co. • Chicago Office: 122 S. Michigan



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. . . used by today's leading designers and manufacturers to create the ultimate in seating comfort.

UNITED STATES RUBBER COMPANY • Rockefeller Center • New York

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- Weiss Cushion Shop
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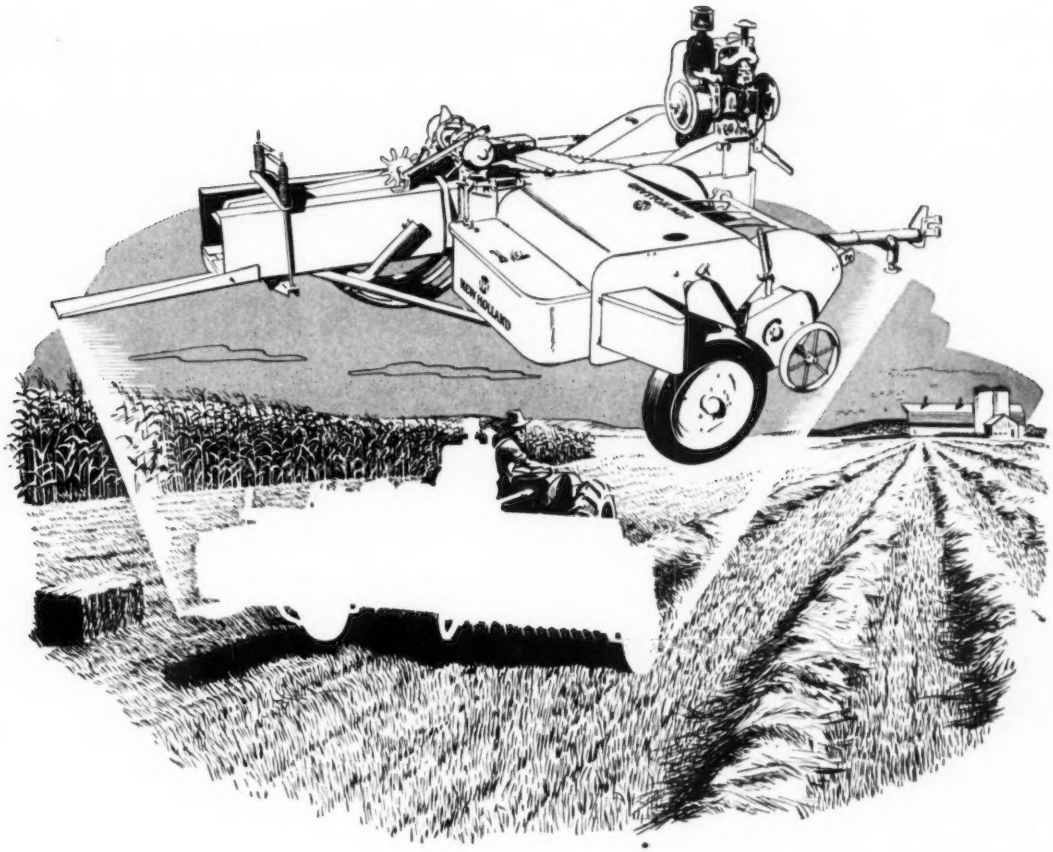


Fits right into the grassland picture

FARMERS with smaller grass acreages face a problem. The size of their grasslands may not warrant a big outlay on equipment and still be too large to manage economically by hand.

New Holland has just placed on the market a baler designed to fit right into this picture. It's the Model 66 twine-tie, the most compact baler ever built.

The lower cost of the "66" makes hay baling practical on almost any size farm. But it's not designed to sell on price alone. It's self-powered, operates with a one-plow tractor. It kicks out up to 6 bales a minute . . . packages up to 7 tons an hour in firm, square bales. It bales anything —clover, prairie hay, maize, sudan grass—dry or semi-cured.

No more depending on neighbors or custom operators—no more frantic forking to beat the weather. With a "66" the small-acreage farmer gets the full benefit of mechanized grasslanding. For now he can put up his hay just at the right stage of curing . . . treat his stock to protein-rich feed.

Development of the "66" began years ago. New Holland engineers, looking ahead, saw the need not for just a small or inexpensive baler, but for a baler that would meet a special need in the growing grassland trend. It's this policy of practical farm engineering that has made New Holland "First in Grassland Farming."

The New Holland Machine Company, a subsidiary of The Sperry Corporation.

NEW HOLLAND

"First in Grassland Farming"

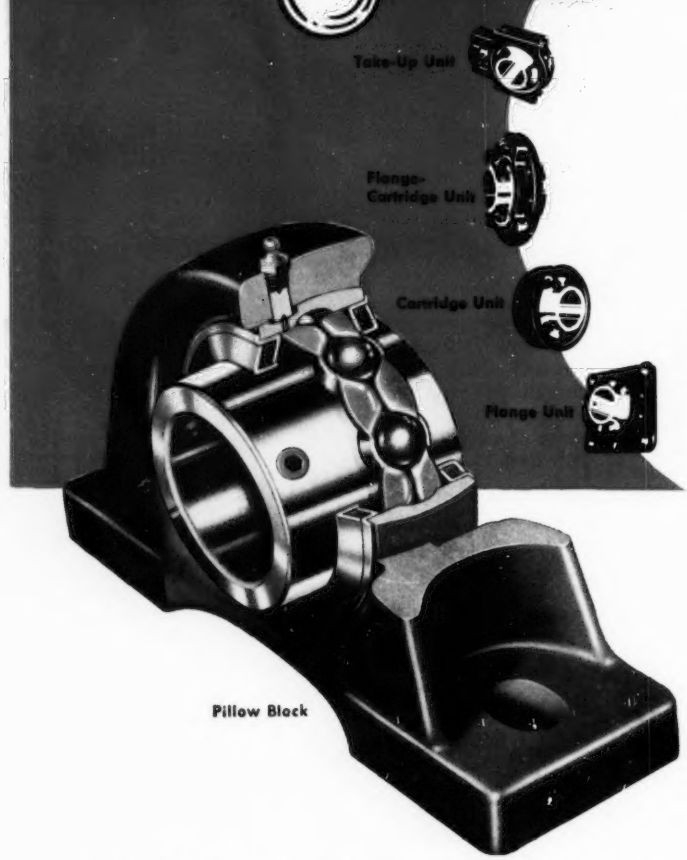
New Holland Pa. • Minneapolis • Des Moines • Kansas City • Brantford, Ontario

YOUR LOGICAL CHOICE

Wherever Bearing Performance and Cost are Important

SEALMASTER

BALL BEARING UNITS



For ALL These Reasons

1. **PERMANENTLY SEALED**
   to exclude dirt and retain proper amount of lubricant.
2. **SELF-ALIGNING**
   in any direction without seal distortion.
3. **PRE-LUBRICATED**
   with the proper amount of lubricant—for long service.
4. **ZONE HARDENING**
   of ball path section of inner race ring, with extended part of race left soft for better race-to-shaft locking.
5. **NO HOUSING WEAR**
   —patented locking pin and dimple prevent rotation of outer race in housing.
6. **FLOATING BALL RETAINER**
   traps lubricant, prevents churning.

To the thoughtful engineer or operating executive, *each* of these SEALMASTER features is a convincing reason for choosing SEALMASTER Ball Bearing Units. *Together*, this exclusive combination of basic advantages offers sound assurance of top performance *under all conditions*. Write now for your copy of Catalog 845—complete data on the broad SEALMASTER line.

SEALMASTER BEARINGS

A DIVISION OF STEPHENS-ADAMSON MFG. COMPANY • 67 RIDGEWAY AVENUE, AURORA, ILLINOIS

FACTORY REPRESENTATIVES AND DEALERS IN ALL PRINCIPAL CITIES

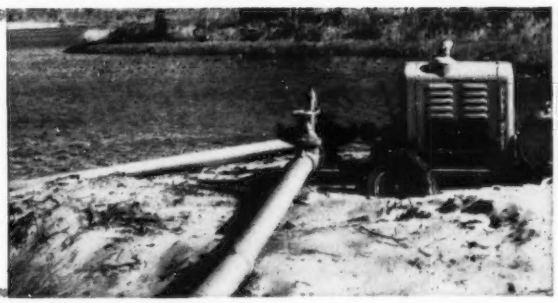
PLOWS 14 MORE ACRES PER DAY

at less than half the fuel cost

"We plow 45 acres in 12 hours where we used to do only 31," says Wesley Ehrlich, big wheat farmer at Shattuck, Oklahoma, who converted a 1942 tractor from gasoline to GM Diesel power in 1949. Pulling a 5-14 moldboard plow to an average depth of 9 inches in black soil of medium density, the GM Diesel-powered tractor *plows one-third more acreage than a gasoline-powered tractor of the same make.* "It's like having an extra farm hand free," says Mr. Ehrlich.

"We've wanted Diesel power for a long time," says Hayes Ganiard, owner-manager of a 600-acre farm near Clark Lake, Michigan. "When we heard about the General Motors Diesel, we had one put in our 3-plow tractor. We've just finished combining and the constant speed of this engine gives us exceptionally clean wheat and a premium price. The Diesel gives us a lot more power, but it uses only 1¼ gallons of fuel oil an hour, compared to three gallons of gasoline. That amounts to a 75% reduction in fuel costs."

Working 100 hours a week during irrigation seasons, this 3-cylinder GM Diesel pumps 1,100 gallons of water per minute through 660 feet of sprinkler line to irrigate the citrus groves of Malcolm Watters, Sebring, Florida. Engine uses only 3 gallons of fuel per hour—requires minimum maintenance. Compactness makes it easy to move around.



DOES ALL FARM JOBS BETTER—

Farmers all across the country are switching to General Motors Diesel power because it gets more work done at lower cost. This rugged 2-cycle Diesel packs more power in less space. It starts quickly in any weather. It uses fewer gallons of safe, low-cost fuel. And, because it is a true Diesel, with no spark plugs, no carburetor or magneto, it is simple to operate, easy to maintain. For the full story, see your GM Diesel distributor or write for illustrated booklet, *"For the Business Man on the Farm."* Learn how much GM Diesel power can save for you!

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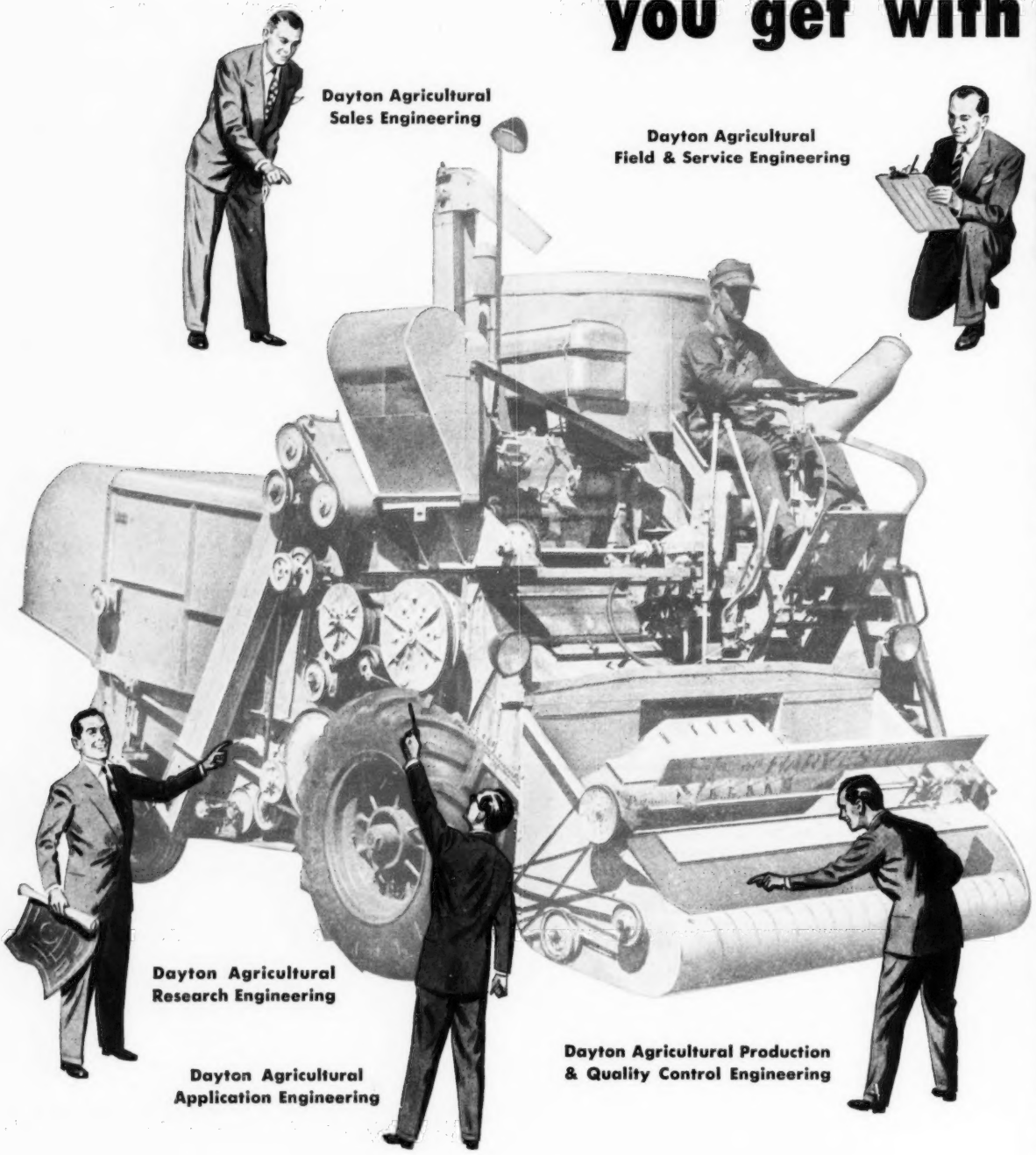
DETROIT DIESEL
ENGINE DIVISION
GENERAL MOTORS • DETROIT 28, MICHIGAN

Single Engines . . . 32 to 275 H. P. Multiple Units . . . Up to 840 H. P.

Agricultural Engineering Experts you get with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COMBINES • CORN PICKERS • FORAGE HARVESTERS
COTTON PICKERS • HAY BALERS • RAKES
MOWERS • WINDROWERS • CHOPPERS
SPREADERS • MILKERS • SPRAYERS, etc.

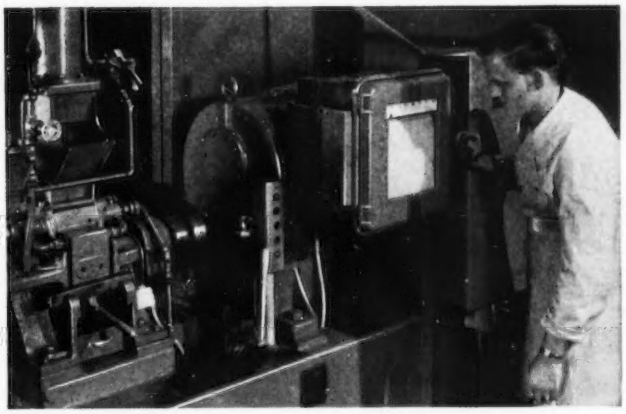
provide the fine SERVICE

Dayton Belts and Rolls

Whether your problem calls for the services of just one of Dayton's staff of agricultural experts—or whether it calls for the skills of all of them—you can be sure of prompt, *informed* assistance when you phone us.

For agricultural belts and rolls aren't just a sideline to Dayton Rubber—our Agricultural Original Equipment Division is a complete organization devoted to developing better rubber products for tough farm use.

If you have any farm implement belt or roll problem, give us a call, and see for yourself. There's no obligation, of course. The Dayton Rubber Company, Agricultural Original Equipment Division, 1009 W. Washington Blvd., Chicago, Illinois.



Does your problem involve research? Then rely on Dayton, makers of the *first* successful V-Belt, and pioneers in rubber research and development since 1905. For example, Dayton developed the process which made it possible to make rubber adhere to steel, and has led the way in developing oil-resistant and anti-freeze rubber.

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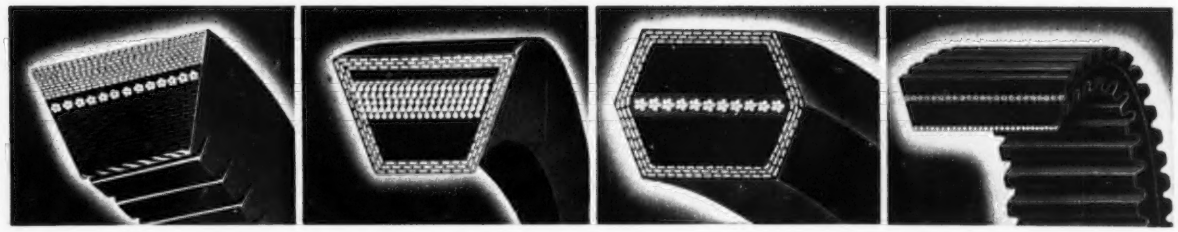
Dayton makes the right belt

FOR EVERY FARM IMPLEMENT!



*Agricultural Cog-Belt** | *Agricultural V-Belt* | *Agricultural Double Angle V-Belt* | *Agricultural Double-Cog Belt**

*T.M.

Dayton Rubber

Since 1905

AGRICULTURAL ORIGINAL EQUIPMENT DIVISION • CHICAGO, ILL.

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with CLEVE-WELD, it's RIMS and RINGS

For most types of rims—or other circular rolled or welded steel parts in quantity—chances are *you can't beat Cleve-Weld*...for quality, uniformity and price!

Here is an organization of engineers, metallurgists and production experts that has specialized in this one field for more than 40 years. Here, too, is a modern plant equipped with machinery especially designed and built by Cleve-Weld for the most efficient mass-production of metallurgically and mechanically uniform circular steel parts. This unbeatable combination supplies rims, rings, bands, gear blanks and other similar parts to many leading manufacturers of tractors, trucks, trailers and agricultural implements...might well be the ideal source of supply for you!

Whatever your requirements in this specialized field, it will pay you to consult Cleve-Weld. Forward your drawings and specs for a free estimate. Out of their broad experience, Cleve-Weld engineers can frequently offer suggestions for slight design changes that will add strength to the part...or reduce its cost of production. Write today!

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A Subsidiary of
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See AMF's exciting, new television show, **"OMNIBUS"**. *Check your local paper for time and channel.*

When Tractor Hydraulic System has a VICKERS Balanced Vane Type Pump

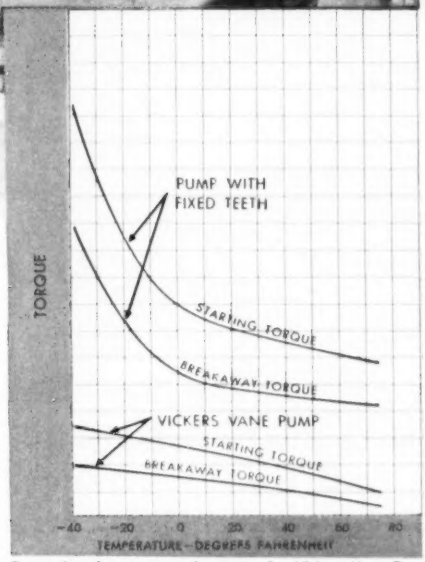
Under the very best conditions, cold weather puts a strain on starting equipment. Every part of the engine is stiffer, and the cold seriously decreases the power of the starting battery. If the hydraulic system has a pump with fixed teeth or lobes, this starting load may be seriously increased above normal.

Vickers Balanced Vane Type Pumps *start at practically no load.* At rest and at normal starting speeds, the sliding vanes are retracted . . . only after the engine fires do the vanes extend and pumping begins. As a result, cold weather starting is much easier when a Vickers Vane Type Pump is used.

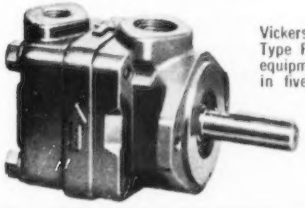
Get in touch with the nearest Vickers office for full information.

(Left) Schematic diagram of Vickers Balanced Vane Type Pump showing how sliding vanes are retracted at normal engine cranking speeds. No oil is pumped and there is practically no starting load.

(Right) Similar diagram of Vickers pump showing how pump vanes are extended when engine is running. Pumping then begins and continues at all engine speeds.



Curves based on comparative tests of a Vickers Vane Type Pump and an equal capacity pump with fixed teeth. Oil used in both complied with Army Spec. 2-79-B.



Vickers Balanced Vane Type Pumps for mobile equipment are available in five basic sizes, 15 normal delivery ratings and a variety of mountings. Ask for new Catalog M-5101.

VICKERS Incorporated
DIVISION OF THE SPERRY CORPORATION
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AGRICULTURAL ENGINEERING

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The L-Shaped Fence Staple

E. George Stern

RESULTS of tests on a new type of fence staple of L-shape with threaded shank of any desired length, are reported in this paper. These results cover the effectiveness of the L-shaped staple, in comparison with that of the commonly used U-shaped staple, with respect to immediate and delayed, axial and angular, static and impact withdrawal resistance in non-treated and creosote-pressure-treated southern pine and locust lumber and fence posts.

The effectiveness of the L-shaped fence staple becomes particularly evident (1) during delayed static tests and (2) during immediate and delayed impact tests, which indicate up to 80 per cent larger average holding power for the L-shaped staple than is provided by the U-shaped staple of the same size.

This increased holding power of the L-shaped staple is especially significant in the creosote-treated southern pine post which offers 40 per cent smaller staple-holding power than the non-treated post.

DESCRIPTION OF STAPLE

The only recently developed L-shaped, threaded-shank fence staple with rounded, inclined head, as shown in Fig. 1, is to replace the presently commonly used U-shaped staple with plain shanks, which is a stock item in many lumber yards, with all building-materials dealers, and in all hardware stores.

The U-shaped staple, although firmly holding immediately after driving, loses its holding power while in use, pops out of the fence post, is easily pulled out, and even drops out as the fence post is exposed to the weather. The new L-shaped threaded-shank fence staple, although of same overall length, provides approximately the same or even larger holding power than the U-shaped staple immediately after driving and possibly considerably larger holding power after it has been in use even only for a short time. While the U-shaped staple continuously loses its holding power until it falls out of the fence post, the threaded-shank staple increases its holding power month by month while in the wood as a result of the type of thread employed along its shank.*

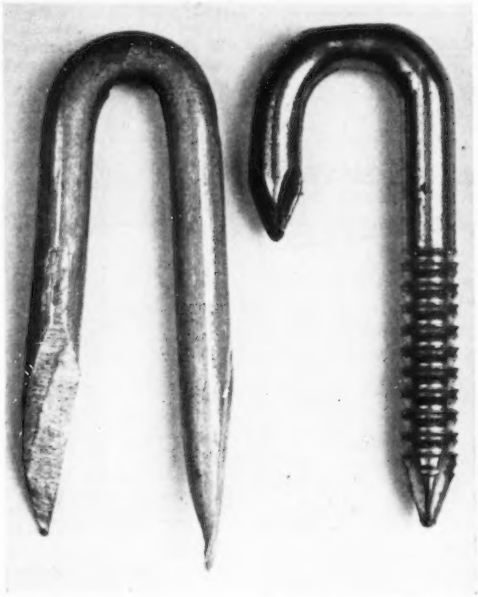

Fig. 1 U-shaped fence staple (left) and L-shaped "Stronghold" fence staple (right)—twice actual size

These characteristics of the L-shaped fence staple are of importance, especially since the use of pressure-treated, creosote-impregnated fence posts becomes more and more predominant. These posts have an anticipated life of 25 to 35 years, in contrast to the non-treated pine posts which often must be replaced within 1 to 2 years. While the U-shaped fence staple in such non-treated short-life posts provides a certain degree of effectiveness, the longer life of the treated fence posts requires the use of a staple which remains as effective as the wire fence, since the treated post outlasts the wire fence. Thus the L-shaped fence staple is designed to be effective for the lifetime of the wire which it fastens to the post.

Furthermore, it has been found that the holding power of the U-shaped fence staple in creosote-impregnated wood is considerably smaller than in non-treated wood. Hence, a more effective staple than the U-shaped is needed to make the fence equally effective if creosote-treated posts are used. Again, the L-shaped staple fulfills the need for a more effective means of fastening than was available prior to its development.

Another important feature of the L-shaped fence staple is based on its shape. Initially, this staple is hammer-driven to a certain depth with part of the long leg penetrating the wood. Then, the wire is placed onto the long staple leg. With a few additional hammer blows, the staple is further driven into the post. Finally, both long and short staple legs penetrate the post, with the staple head firmly holding the wire. Hence, it is no longer necessary to hold both wire and staple in one hand during staple driving, since the L-shaped staple can be started *before* the wire is stretched and hooked onto the staple.

The L-shaped staple is the out-

This paper was prepared expressly for AGRICULTURAL ENGINEERING, and reports on an investigation in the Wood Research Laboratory of the Virginia Polytechnic Institute under the sponsorship of the Independent Nail and Packing Co., Bridgewater, Mass., manufacturer of the new fence staple. Further detailed information and test data are presented in Virginia Polytechnic Institute Wood Research Laboratory Bulletin No. 11 (in press).

The author—E. GEORGE STERN—is research professor of wood construction, Virginia Engineering Experiment Station, Virginia Polytechnic Institute.

*Increases in holding power amounting to as much as 70 per cent during one-year, accelerated, severe exposure are described in Virginia Polytechnic Institute Wood Research Laboratory Bulletins No. 5 of August, 1951, entitled "The Lasting Efficiency of Flooring Nails," and No. 8 of April, 1952, entitled "Immediate vs. Delayed Holding Power of Nails."

come of considerable development work. To facilitate easy driving without buckling, the *head* first was designed with an offset. Later an inclined bridge, connecting the long and short staple legs, proved to be more satisfactory, more efficient, and easier to manufacture. The incorporation of several small improvements in this head design, such as providing fillets by rounding out the head, led to a staple, as shown in Fig. 1, which provides a balanced design between staple head and shank for many applications and service conditions.

The *points* of the staples may be diamond points or sheared points, the latter being more economical to manufacture. When driven into very hard woods, sheared points provide many advantages and their use may be a necessity.

The L-shaped staple is manufactured in any desirable *length*, with the selection of the staple length depending on the wood species of which the post consists. For hard woods, a short staple is used, while a longer staple is required for the soft woods. A staple length of 1½ in appears to be desirable for treated southern pine posts.

While the *gage* of the low-carbon-steel wire may vary within narrow limits, a 9-gage (0.148-

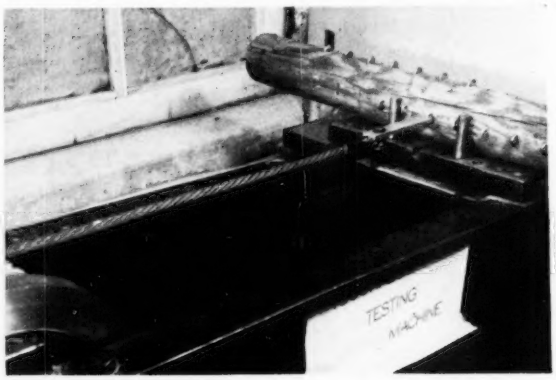

Fig. 2 Setup for performance of comparative impact withdrawal tests on U-shaped and L-shaped fence staples in creosote-treated southern pine fence posts. (Impact is applied to the staple through a cable wound around the pendulum-supporting, rotating steel drum at lower left)

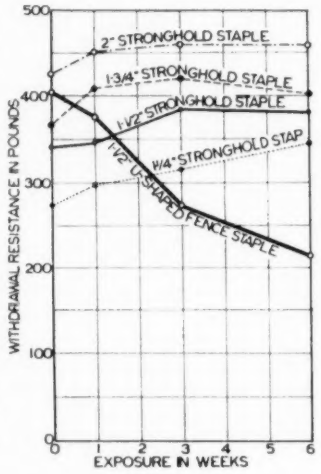

Fig. 3 Average, immediate and delayed, axial withdrawal resistance of rounded-head, L-shaped Stronghold fence staple and standard U-shaped fence staple immediately after driving into green southern pine and after exposure of test plank for 1, 3, and 6 weeks to 50 per cent relative humidity at 70 F temperature

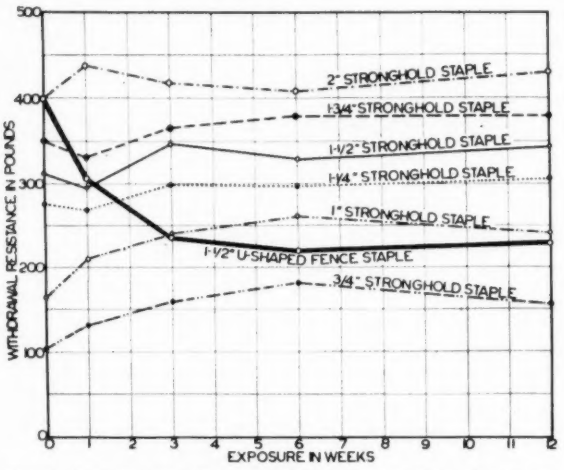

Fig. 4 Average, immediate and delayed, axial withdrawal resistance of rounded-head, L-shaped Stronghold fence staples and standard U-shaped fence staple immediately after driving into creosote-treated southern pine fence posts and after their exposure for 1, 3, 6 and 12 weeks to 50 per cent relative humidity at 70 F temperature

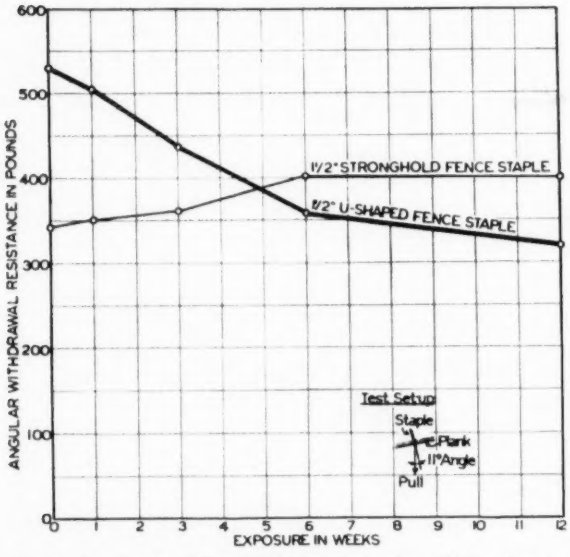

Fig. 5 Average, immediate and delayed, angular withdrawal resistance of 1½-in long, rounded-head, L-shaped Stronghold fence staple and standard U-shaped fence staple immediately after driving into green southern pine and after exposure of test plank for 1, 3, 6, and 12 weeks to 50 per cent relative humidity at 70 F temperature

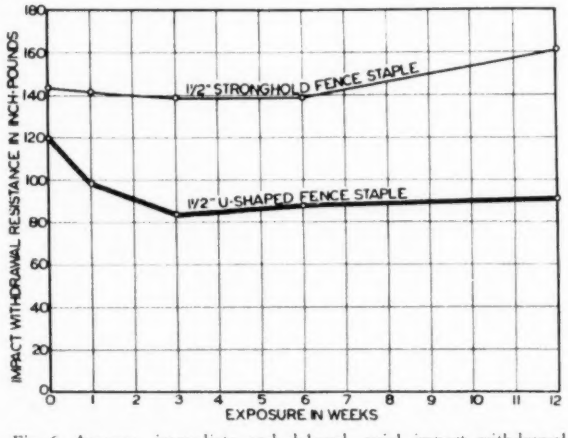

Fig. 6 Average, immediate and delayed, axial impact withdrawal resistance of 1½-in long, rounded-head, L-shaped Stronghold fence staple and standard U-shaped fence staple immediately after driving into green southern pine and after exposure of test plank for 1, 3, 6, and 12 weeks to 50 per cent relative humidity at 70 F temperature

TABLE 1. PER CENT CHANGE IN HOLDING POWER DURING EXPOSURE

Withdrawal resistance*	Test lumber	Galvanized, U-shaped, 1½-in staple during given weeks of exposure 1	3	6	12	L-shaped, threaded-shank, ¾ to 2-in staples during given weeks of exposure 1	3	6	12
Static-axial	Green southern pine	−7	−32	−47	.....	+7	+13	+14	.....
Static-axial	Creosoted southern pine post	−23	−41	−45	−42	+9	+21	+26	+23
Static-axial	Green locust post	.....	.....	.....	.....	+4	−1	.....	.....
Static-axial	Green southern pine	.....	.....	.....	.....	−12	−3	+4	.....
Static-angular	Green southern pine	−5	−18	−32	−39	+3	+6	+17	+17
Impact-axial	Green southern pine	−18	−30	−27	−24	−1	−3	−3	+13
Impact-axial	Green southern pine	.....	.....	.....	.....	−2	−6	−7	.....

*(+)=gain; (−)=loss.

TABLE 2. PER CENT IMMEDIATE HOLDING POWER OF L-SHAPED STAPLES COMPARED WITH U-SHAPED STAPLE

Withdrawal resistance*	Test lumber	For given lengths of L-shaped staples ¾ in	1 in	1¼ in	1½ in	1¾ in	2 in
Static-axial	Green southern pine	−73	−55	−32	−16	−9	+5
Static-axial	Creosoted S. P. post	−74	−59	−31	−22	−12	+1
Static-angular	Green southern pine	.....	.....	.....	−35	.....	.....
Impact-axial	Green southern pine	.....	.....	.....	+19	.....	.....
Impact-axial	Non-treated S. P. post	.....	.....	.....	+21	.....	.....
Impact-axial	Creosoted S. P. post	.....	.....	.....	+26	.....	.....

*(+)=larger; (−)=smaller.

TABLE 3. PER CENT DELAYED HOLDING POWER OF L-SHAPED STAPLES COMPARED WITH U-SHAPED STAPLE

Withdrawal resistance*	Test lumber	During given weeks of exposure 1	3	6	12
Static-axial	Green southern pine	−8	+41	+78	.....
Static-axial	Creosoted S. P. post	+3	+44	+50	+50
Static-angular	Green southern pine	−30	−17	+12	+23
Impact-axial	Green southern pine	+45	+64	+58	+78

*(+)=larger; (−)=smaller.

in) wire proved to be most satisfactory from a number of viewpoints.

Like the U-shaped staple, the L-shaped staple is manufactured with a bright *finish* or galvanized, be it electroplated or hot-dipped. For special purposes, the L-shaped staple is made of copper, brass, bronze, stainless steel, and monel.

Throughout the development period, fully comparative, immediate and delayed, static and impact withdrawal tests were performed on the relative efficiency of the threaded-shank, L-shaped staples of different lengths, in comparison with that of the U-shaped staple, in non-treated and creosote-impregnated, green and dry, southern pine planks and fence posts. With every design change, additional laboratory and field tests were initiated. Thus, a relatively large amount of data is presently available on these L-shaped staples. Additional data emanating from field tests under way in almost all southeastern states, ranging from Virginia to Texas, should become available within a relatively short time thanks to the cooperation of the various agricultural experiment stations of a number of land-grant colleges, the Tennessee Valley Authority, and the Koppers Company. For this purpose, the L-shaped, threaded-shank staples were produced in relatively large quantities and freely made available to the cooperating agencies. Thus, the resulting data should provide a convincing picture of the benefits derived by the use of this new staple.

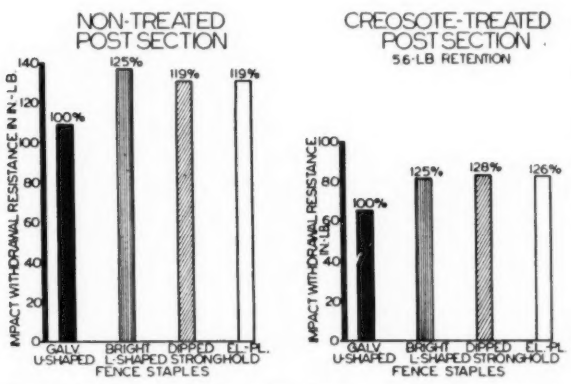

Fig. 7 Average, immediate, axial impact withdrawal resistance of 1½-in long, bright-finished and galvanized, rounded-head, L-shaped Stronghold fence staples and galvanized U-shaped fence staple, immediately after driving into non-treated and creosote-pressure-treated sections of southern pine fence post of 27 and 26 per cent moisture content, respectively

TEST PERFORMANCE

The static withdrawal tests were performed at a rate of motion of 0.060 in per min of the pulling crosshead of the 1000-lb capacity Olsen universal testing machine. The impact tests were performed with the U.S. Forest Products Laboratory-designed VPL-built toughness testing machine with the initial pendulum angle at 45 deg and the pendulum weight at position 5. The impact-test setup is shown in Fig. 2.

TEST RESULTS AND CONCLUSIONS

Static Tests. The average, immediate and delayed, axial withdrawal resistance of L-shaped and U-shaped fence staples after driving into green southern pine is given in Fig. 3. Similar matched data for staples driven into creosote-pressure-treated southern pine fence posts are graphically presented in Fig. 4. Similar data on the angular axial withdrawal resistance are shown in Fig. 5.

Impact Tests. The average, immediate and delayed, axial impact withdrawal resistance of 1½-in long, L-shaped and U-shaped fence staples after driving into green southern pine is presented in Fig. 6, and after driving into non-treated and creosote-pressure-treated sections of a southern pine fence post is shown in Fig. 7.

The presented data confirm the experience gained in the field, that is, show a radical *loss* in holding power of the U-shaped fence staple and maintenance or even *gains* in holding power of the L-shaped, threaded-shank fence staples during identical exposure conditions. These data are summarized in Table 1 on a percentage basis with respect to initial holding power.

The large losses in holding power of the U-shaped staple during exposure appear to be the principal reason for the numerous complaints concerning the relative ineffectiveness

of the U-shaped staple, be it bright-finished or galvanized.

On the basis of the *initial* holding power of the 1½-in long, galvanized, U-shaped staple, that of the L-shaped staples of given lengths is presented in Table 2.

On the basis of the one, three, six, and twelve-week *delayed* holding powers of the 1½-in long, galvanized, U-shaped staple, those of the same-length, L-shaped staple amount to the percentage values given in Table 3.

From these tabulated data it becomes evident that the benefits derived by use of the L-shaped staples become particularly apparent during service conditions.

Furthermore, the described large losses in holding power of the U-shaped staple and the maintenance or even gains in holding power of the L-shaped staples become especially significant with the predominant use of creosote-treated fence posts, since the impact withdrawal resistance of the U-shaped and L-shaped staples in creosote-pressure-treated southern pine posts is 40 to 38 per cent, respectively, smaller than in matched non-treated posts.

The holding power of hot-dipped and electroplated galvanized, L-shaped staples appears to be similar. If compared with that of the bright-finished, L-shaped staple, it is the same according to static tests and somewhat larger according to impact tests.

Hence, on the basis of the laboratory data presented, considerably better field service can be expected from the L-shaped threaded-shank fence staples than is rendered by the U-shaped fence staples presently in common use.

New Developments in Potato Storage

Alfred D. Edgar
MEMBER ASAE

POTATO storage design is influenced by the varieties grown, size and relative importance of the crop; by local climate, topography, subsoil and drainage; by transportation facilities and building and management practices, and by labor, handling and marketing methods.

Local climate during storage season determines whether potatoes should be kept under refrigeration, in common storage, or in heated storage, for long periods. (Potatoes can be kept frost and sprout free up to 90 days under 32 - 55 F temperature range.) Climate affects ground temperature so it is as important as the topography, subsoil and drainage, in determining whether underground storages are practical. Where average annual temperatures are about 40 F, underground storages are quite useful for keeping small quantities of seed for long periods, with a minimum of attention. In dry climates and with good drainage, the subsoil heat storage, and earth insulation may be depended upon, but soil regulation cannot be adjusted to special requirements. In some areas the soil holds up and serves as a wall against which potatoes may be stored, but usually an air-circulation space should be between the potatoes and the outside wall, whether it is earth, masonry or insulated frame construction.

It has been common practice to divide storage into bins 8 to 10 ft wide. For better gravity circulation double-slatted partitions were used, especially in warmer climates. (Here the partitions are at 60 deg with alleys, permitting trucks to back into bins.) These partitions often double the cost of storage space. With forced circulation partitions are needed only to separate potatoes due to varieties, quality or ownership. Small buildings are relatively expensive, so small lots of potatoes are often stored in portions of buildings built for other purposes. Heat produced by potatoes is proportional to the volume of potatoes, while heat dissipated is proportional to exposed areas. Where the quantity is small, fall cooling is easy, but winter holding difficult; and where large, fall cooling is difficult and winter holding easy. Generally more insulation and less circulation are needed for the small, than for the large storage.

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1952, as a contribution of the Farm Structures Division.

The author—ALFRED D. EDGAR—is senior agricultural engineer, division of farm buildings and rural housing (BPISAE), U.S. Department of Agriculture.

Local building practices are usually a fair guide in storage design because these are based on experience with climate, local handling, and marketing methods, and on available materials and transportation facilities. But controlling factors are changing. Farm storage of table stock was a good idea when the labor and transportation problems in moving potatoes to track storage at harvest time were more critical than moving them from farm storage to track at shipping time. (With better highways, heated or refrigerated trucks, farm storages may also be shipping plants.) The loading of refrigerator cars in cold weather has been made safe by the adjustable holding frame for the canvas loading tunnel.

The two-story house, the basement storage and the partly underground storage had advantages in economy of construction and use of labor, that are lost when upper driveways are built to support present heavier truck loads, when bin partitions and walls must be made stronger for greater storage depths and when potato injury losses are greater than handling labor savings.

Storage conditions can be regulated manually by using gravity circulation and ventilation just like a home heating system can be regulated manually. In both cases the bigger the installation, the greater the advantage of automatic control. In this paper we are considering common storage only, and thermostatic regulation of ventilation is a critical matter. In a refrigerated or a heated storage, thermostats are set to cool or heat when needed. In a common storage, thermostatic control consists of one control calling for cooling, but a second control holding off operation until outside air is suitable. Cooling then takes place until the first control has enough, or until the outside air is no longer suitable. Adequate insulation is the first consideration in present-day storage design. At one time builders were told that 2 to 4 in of insulation was enough. More insulation would make fall and spring cooling difficult. High storage humidity is desirable to reduce potato shrinkage, but becomes undesirable if it results in ceiling condensation and dripping on the potatoes. Now with forced-air circulation and automatic ventilation to remove all potato heat, 6 to 12 in of insulation is practical and it permits high wintertime humidity.

(Continued on page 258)

Measurement of Grain Pressures on Bin Walls and Floors

Robert A. Saul
ASSOC. MEMBER ASAE

THE study reported in this paper is being made in flat-type grain-storage bins such as are used in farm grain storage and government-owned grain storage. The objectives are to find the relationships between bin dimensions and the distribution of pressures on the walls and floors; the effects of studs, girts, and braces exposed to the grain upon the distribution of pressures; the effects of flexibility of the structural frame and local flexibility of wall sheeting; the effects of wall-liner material, sloping walls, filling methods, grain moisture content, and of time upon pressure distribution. This is a progress report on the investigation which was begun in March, 1950. It includes a discussion of some conditions which cause variations in pressure distribution and experiences with instrumentation.

The study up to the present time has been made in a rectangular wooden frame bin 12 x 32 ft in plan with walls 10 ft high which was erected at the grain storage bin site on the Iowa State College agricultural engineering experimental farm. The walls were framed with 2 x 6-in studs, approximately 16 in on center with a single covering of car siding attached to the inside of the studs, the siding boards running horizontally with the grooved side next to the grain. The floor was laid on double 2 x 6-in joists 24 in on center supported by cement blocks above a concrete slab. The opposite walls were tied together at the plate line and then stiffened with a truss brace on the outside bearing against a 4 x 4-in timber running horizontally around the bin 4 ft above the floor.

Grain pressures were measured with panels which were, in effect, small areas of the floor or wall each of which was supported by a weighing device. A panel support was used which would weigh both the load normal to the panel face and the load parallel to the panel face due to the friction of the grain on the panel. The panels used in this study were adapted from the panels used by McCalmont and Ashby (1)* to measure wall pressures in corn cribs and later adapted by Henderson (2) to measure shelled corn pressures in cylindrical steel bins. The wood panel (A, Fig. 1) had an exposed face of 1 sq ft. It was supported by two ⅝-in-diameter cold-rolled steel rods (B, Fig. 1) which, in turn, were supported by two steel beams of T section (C, Fig. 1) that replaced studs in the wall and joists in the floor. The attachment of the panel to the two steel rods was made by two steel angles (D, Fig. 1) which were fastened to the back of the panel and had holes provided to take the rods. There were 19 panels one above the other in the wall and 21 panels side by side across the floor. A plane passing through the center line of the panels was 13½ ft from one end wall and 17½ ft from the other. The inside bin dimensions were 11 x 31 ft.

As can be seen in Fig. 1, each rod was essentially a simple beam to which were applied two equal concentrated loads symmetrically placed. There were at least two methods of using the known relationships of such a beam to measure the loads applied. McCalmont and Ashby measured the change in deflection of the midpoint of the rod to determine the load. In this study, the strain produced on the extreme fibers of the rod at midspan was used to determine the load which produced the strain. Bending with the accompanying strains would be produced in the rods in planes parallel to the plane of the load applied to the panel. Strains were measured in two planes—a plane normal to the panel face and a plane parallel with the panel face. A compressive strain would be produced on the side of the rod nearer to the load and tensile strain on the side of the rod farther from the load. These strains were measured with bonded wire, electrical resistance strain gages. Four type A-7, SR-4 strain gages (3) were bonded to each rod, two gages to measure the compressive and tensile strains in the plane normal to the panel face and two gages in the plane parallel with the panel face (Fig. 1). There were four gages for each panel for each component of the load applied to the panel, two on each rod. The four gages on each panel, in the positions to measure the strain produced by the load normal to the panel face, were connected in a Wheatstone-bridge circuit in such a manner that the reduction in electrical resistance of the gages due to compressive strain would add to the increase in resistance due to tensile strain, and thus produce a reading of total strain approximately four times the reading that would result if only one gage were used. The four gages on each panel in the positions to measure the strain produced by load applied parallel with the panel face were connected in another bridge circuit, there being 80 such circuits altogether for 40 panels.

At the same time, temperature compensation for the difference in thermal expansion between the gages and the rods was automatically taken care of because the tension and compression gages of one rod were connected to opposite sides of the bridge. A change in temperature would cause either an increase or decrease in strain of both gages which would be cancelled in the circuit. Each bridge circuit was

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1952, as a contribution of the Farm Structures Division. Approved as Journal Paper No. J2195 of the Iowa Agricultural Engineering Station, Project No. 587.

The author—ROBERT A. SAUL—is assistant agricultural engineer (BPISAE), U.S. Department of Agriculture.

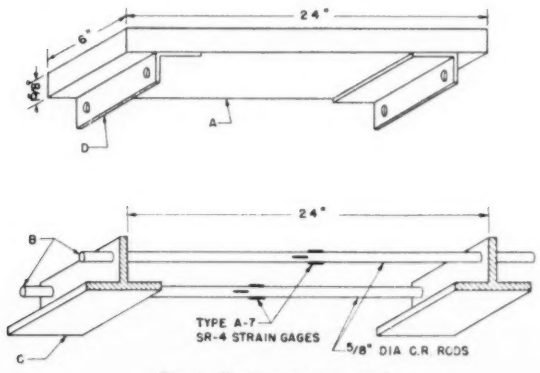

Fig. 1 Grain-pressure panel

*Numbers in parentheses refer to the appended references.

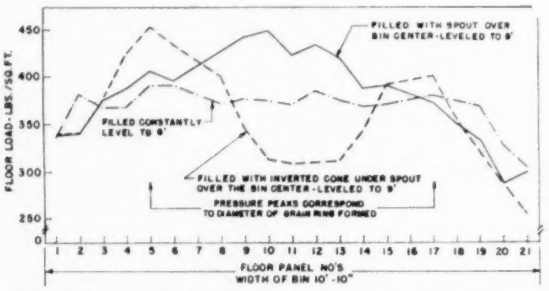
FILLED WITH SPOUT OVER BIN CENTER-LEVELED TO 9'
FILLED CONSTANTLY LEVEL TO 9'
FILLED WITH INVERTED CONE UNDER SPOUT OVER THE BIN CENTER-LEVELED TO 9'
PRESSURE PEAKS CORRESPOND TO DIAMETER OF GRAIN RING FORMED
FLOOR LOAD-LBS./SQ.FT.
FLOOR PANEL NO'S
WIDTH OF BIN 10'-10"

Fig. 2 Distribution of vertical floor load across the center of an 11 x 11-ft bin

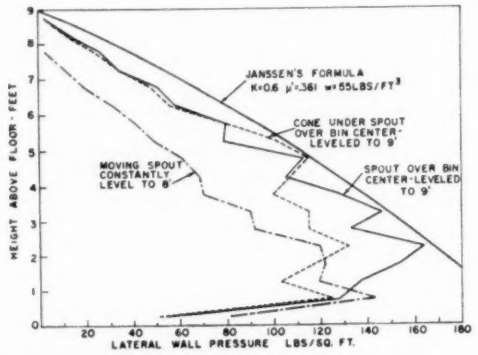
JANSSEN'S FORMULA
CONE UNDER SPOUT OVER BIN CENTER-LEVELED TO 9'
MOVING SPOUT CONSTANTLY LEVEL TO 8'
SPOUT OVER BIN CENTER-LEVELED TO 9'
HEIGHT ABOVE FLOOR-FEET
LATERAL WALL PRESSURE LBS/SQ. FT.

Fig. 3 Distribution of lateral wall pressures with depth in the center of one wall of an 11 x 11-ft bin

connected to one of eight 4-wafer, 11-position, rotary switches. Each switch was connected to the strain-indicating instrument by a master rotary switch. Strain readings could be made from the 80 strain-gage circuits in less than 30 min. Each panel was calibrated by applying known loads of lead weights to determine the indicated strain per pound of load.

Zero readings before and after the first filling of the bin with shelled corn differed by 20 to 30 microinches of strain or 10 to 15 lb per sq ft of pressure on the panels. The zero drift of the instrument, due to temperature and battery voltage changes, was found to be of the same magnitude as the reported deviations. Therefore, two readings were obtained for each circuit by reversing the two leads from the instrument to either the input side or comparison side of the bridge circuit. The average of these two readings provided an instrument zero. With the instrument zero at the no-load readings as reference, corrections to subsequent readings with corresponding instrument zero averages were applied by adding, with the proper sign, the difference of the averages to the strain readings. This procedure reduced the differences between successive no-load readings to 2 lb per sq ft or less. With a depth of 8 ft of shelled corn, this would be an error of less than 1 per cent of full load on the floor panels and the error due to zero drift was of the same magnitude on the wall panels even though the load per panel decreased, because the indicated strain per pound of load was made increasingly greater on the wall panels from bottom to top by increasing the distance between the rod supports and the points of load application.

During the warm humid weather of the summer months, difficulties were encountered in two ways. The first one was a breakdown of the insulation between the bonded wire of the strain gage and the steel rod even though Petrosene wax had been applied immediately after the gages had been bonded to the rods and the duco-type cement dried by placing the rods in an oven, in compliance with instructions furnished by the gage manufacturer. It is believed that the wax protection may have been damaged while connecting the gages to the instrument lead wires and there may not have been a sufficient coating of wax. The rods were removed from the panels, the soldered connections between the lead wires and the gages painted with Glyptol paint, the rods heated in the oven at 175 F until the resistance between the gage and the rod was restored to 1000 megohms or more, and a heavy coat of Petrosene wax was reapplied. This treatment has maintained the insulation of the gages through a winter and the following very humid summer with protection only from direct wetting by rain or snow. The second difficulty, caused by the humid weather, was a breakdown of the insulation within the rotary switches. This was corrected by circulating a stream of dehydrated air through the switches.

It was necessary to provide a space around each panel to allow it to act independently of the adjacent panels and of the bin floor or wall. This space was from ⅛ to ¼ in in width. Cracked corn and dust became lodged in these spaces. It was found, however, that a crepe-paper covering, 40 in wide, over the panels allowed freedom of action for the individual panel and kept out the cracked corn and dust.

The bin has been filled and emptied 15 times to date. The inside bin dimensions for the first three fillings were 11 x 31 ft and later the size was reduced to a square bin 11 x 11 ft with the panels in the center of the wall and across the center of the floor. The bin was filled in each test with shelled corn with an average test weight of 57½ lb per bu and an average moisture content of 12.5 per cent. It was elevated in and out by a Vac-U-Vator grain elevator from adjacent storage bins.

It was not economically feasible to weigh the corn which was put into the bin, so an approximation of the total weight had to be made. A unit weight based on the test weight as determined by the standard method is probably near the lower limit. The upper limit would depend upon the compaction of the grain due to the method of filling, the depth of the grain and disturbances such as vibration. Comparison between the shelled corn densities of loose fill and packed fill in a 8-in-diameter bin as reported by C. K. Shedd (4) shows a maximum increase of approximately 5 per cent.

The grain was spouted into the bin in three different ways: first, by fixing the spout above the center of the bin and allowing the grain to pile up until enough grain was in the bin to level it off to the desired depth; second, by placing a small cone-shaped deflector just below the spout which caused the grain to pile up in a larger conical pile with a hollow or depressed center, and, thirdly, by filling the bin with a moving spout adding 2 ft of depth at one time, keeping the surface essentially level without the grain moving or sliding once it was placed. The distribution of the load on the floor-pressure panels reflects the method of filling as is shown in Fig. 2.

Three different bin loadings were observed for periods of several days, two for 18 days and one for 25 days. The maximum variation between readings of the wall pressures during this period was small with no apparent tendency to steadily increase or decrease. The indicated pressure on the

floor panels increased with each reading for 18 days in all three cases. The indicated pressures were the same between the 18th and 25th day for the loading observed for that period. The loadings observed for 18 days were made with a moving elevator spout which maintained the corn surface level at all times. One loading was made to an 8-ft depth and the other to a depth of 6 ft. The loading observed for 25 days was made with the spout fixed above the bin and enough corn elevated to fill it to a 9-ft depth when it was leveled. This method of filling did not produce a uniform load on the floor. But with the other two fillings, care was taken to make the loading uniform. The curve showing the pressure readings taken on the 18th day with the 8-ft depth in Fig. 2 indicates that the floor pressures were essentially uniform. In these cases, the assumption that the weight of the corn in the section of the bin directly above the floor panels should be measured by the sum of the vertical pressure readings of the floor panels plus the vertical load carried by the walls at both ends of the floor panel section seemed valid. A close approximation to this vertical wall load would be twice the sum of the vertical wall pressure readings on the wall panels at one end of the floor panel section. In both of these cases of uniform filling, this assumption was not borne out until the 18th day after filling.

The explanation for these results may be that the movement of the panel with respect to the floor or wall adjacent to it causes an arching or bridging of the grain over the panel. The bridging then breaks down after a period of time. The panel deflection for the floor panels under a load of 8 ft of corn is approximately 0.008 in and the deflection of the wall panels varies from 0.004 in at the bottom of the wall to 0.002 in at the top.

WALL-SUPPORTED LOAD DECREASES FLOOR LOAD

Examination of the pressure distribution curves in Fig. 2, and similar curves for all of the tests which have been carried out, show a decrease in floor load in the area next to walls. This decrease in load was due to vertical load supported by the walls. In all tests, the relief on the floor panels next to the south wall, as represented by the right-hand boundary of Fig. 2, was greater than that on the floor panels next to the north wall (left side, Fig. 2). The wall panels were placed in the south wall and the steel beams of Tee section used to support the rods replaced the 2 x 6-in studs, which made the south wall at this section less flexible than the north wall. The load distribution on the floor indicates that the less flexible wall assumed a greater vertical load.

Fig. 3 shows the lateral pressure distribution on the wall for the same fillings as were discussed with reference to Fig. 2. The pressures represented in Fig. 3 by the solid line are as great as were measured in all but one filling. In this one filling, the grain was spouted into the bin just above the wall opposite the wall with the pressure panels and allowed to flow toward the panels and the pressures were higher than those reported. When the bin had been filled, it was noticed that the walls had been tilted by the unsymmetrical loading in such a way that the wall-pressure panels were pulled into the grain which would cause higher pressures on the panels due to the passive resistance of the grain. Fig. 3 also shows the pressure distribution calculated from Janssen's formula using a K value of 0.6 and coefficient of friction of the grain on wall of 0.361 and a unit weight of 55 lb per cu ft, as recommended in U.S. Department of Agriculture Circular No. 835, "Grain Bin Requirements."

The observation of the lateral wall pressures for all depths of fill in each of the 15 loadings showed a falling off of pressure just above the floor. This is shown in Fig. 3. Observation of the friction pressure of the corn on the floor panels showed a big increase near the walls. It appears logical that the lateral wall pressure is relieved by the lateral pressure supported on the floor in the same manner as the vertical floor pressure is relieved by the vertical load supported on the wall. The operation of the panels affected was carefully checked to insure that these observations were not due to defects in their operation.

EFFECT OF EXPOSED STUDS ON WALL-PRESSURE DISTRIBUTION

A study of the effects of exposed studs upon the wall-pressure distribution was begun. Three fillings with different stud arrangements were made and two fillings without studs, one before and the other after the stud tests. In all these tests, the bin was filled with shelled corn from a moving spout maintaining a level, uniform fill to a depth of 8 ft, except in the final no-stud test, when the bin was filled to a depth of 6 ft. A 2 x 10-in stud was placed in the center of the wall panels for the first test. It was fastened at the bottom to the floor panel adjacent to the wall and at the top wall panel. A clearance of approximately ¼ in between the stud and the wall panels was provided. The load on the stud was measured by readings obtained from the panels to which the stud was fastened. Because of the panel area shielded by the stud a correction factor of 1.07 was applied to the pressures indicated by each panel to reduce the pressures to a pound-per-square-foot basis. This stud was then removed and a 2 x 10-in stud was fastened to the wall on each side of the panel for the second test. These were replaced by 2 x 6-in studs for the third test.

There was no significant difference between the results of the first two stud tests. In each case the total lateral load on the panels was about 30 per cent less than the first no-stud filling. In the first test, with the stud fastened to panels, this difference was accounted for by the load measured on the stud. In the third test with the 2 x 6-in studs, the lateral load on the panels was about 20 per cent less than the first no-stud filling. The second no-stud test gave lateral pressures of about 12 per cent less than the first no-stud test.

This difference was attributed to the increase in dust and cracked and damaged corn caused by repeated elevating. A comparison of graduated sieve analysis of samples of the corn from both no-stud tests indicated an increase of 310 per cent in the dust and fine material passing through the last sieve with 6/64-in-diameter openings. About 775 bu of shelled corn were required to fill the test bin. This corn was taken from the bottom of a 2700-bu cylindrical bin and elevated back into the top of it. The five fillings for the stud study represent the fourth through the eighth times the grain was removed and replaced in the supply bin. The difference due to the increase in dust and damaged corn did not erase the stud effects but a quantitative analysis was eliminated.

During the summer of 1951, Iowa State College with the cooperation of the Stran Steel Division of the Great Lakes Steel Corporation erected a quonset 32, 72 ft long, housing a quonset 20, 48 ft long, to be used for grain-pressure studies. In September of this year, the moving of

the pressure panels to the quonset 20 was begun. Because this bin is on a more rigid foundation and floor, wall deflection can be measured. Also, it will be possible to elevate the grain without the damage experienced before.

SUMMARY OF RESULTS

1 With the use of Glyptol paint to insulate the bared lead wires and the proper application of Petrosene wax, SR-4 strain gaging will remain effective over a long period of time with protection only from direct wetting by the weather.

2 Changes in indicated strain readings due to electronic changes within the indicating instrument caused by temperature changes, battery voltage drop, or other effects can be eliminated by the use of an instrument zero as basis for correction obtained by reversing the connections to the gages.

3 The method of filling a bin will influence the distribution of grain load on the walls and floor as is shown in Figs. 2 and 3.

4 The flexibility of the wall structure will influence the distribution of grain pressures. The more rigid the wall, the greater will be the load carried by the wall.

5 In a stud-framed bin without an interior liner the total lateral wall load is about the same as that for a lined wall, but the pressure against the sheathing is less than against a liner, the difference in load being taken directly by the studs.

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Cotton Picker Sacking Attachment for Harvesting Small Plots

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A SACKING attachment for a mechanical cotton picker was developed in 1952 by agricultural engineers of the A. & M. College of Texas to facilitate the harvesting of small field plots. This attachment (Fig. 1) consists of an inverted U-shaped duct which is joined at one end to the regular basket duct. A two-way lip valve is installed at the junction of the sacking duct and the regular duct. A lever on the outside is conveniently located so that the picker operator can easily and quickly flip the valve. Swinging the valve across the regular duct allows the cotton to be blown into a sack hooked to the opposite end of the sacking duct. When the valve is swung across the opening into the sacking duct, the cotton is blown through the regular duct into the cotton picker basket.

Fig. 2 shows the position of a small platform for a man to stand on while handling the sacks.

In operation, a man standing on the platform between the sacking attaching duct and the picker basket handles the sacks for the plots. The plots and alleys are marked by a series of high stakes so that a man on the ground can signal the operator when to stop. Another man with data sheets and portable spring scales follows the machine to weigh and record the cotton as it is picked from the plots. Helpers carry the weighed sacks to a trailer and empty them.

A total of 275 field plots were harvested in 1952 with this equipment. When the data were analyzed statistically the results were comparable with hand-harvested plots. Hand labor for harvesting field plots requires close supervision and is becoming difficult to obtain. A sacking attachment on a mechanical cotton picker that uses an air-conveying system will enable research workers to harvest field plots in a relatively short time with a minimum amount of labor.

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The authors — H. P. SMITH and E. C. BROWN — are, respectively, professor and instructor in agricultural engineering, A. & M. College of Texas.

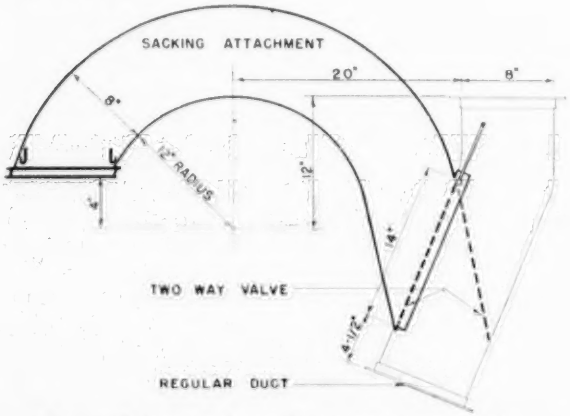

Fig. 1 Sacking attachment for mechanical cotton picker

Fig. 2 Sacking attachment in use. Note sack attached to duct and resting on platform

Absorption of Solar Radiation by the Hair of Cattle

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TEMPERATURES exceeding 80 F, not uncommon for American summers, reduce milk flow in dairy cows, egg production in poultry, and weight gains in hogs and beef cattle. The stress of high temperature is greatly aggravated by exposure to solar radiation, as during grazing. A partial solution of the problem has been to provide artificial shades where no trees are available (10, 11)*. Analysis of the value of shades demands knowledge of the precise way in which the solar energy behaves upon striking the animal surface. Calculation of the solar-heat load must necessarily be based on such knowledge.

Furthermore, it has been assumed since ancient times that heat tolerance in cattle is partially correlated with ability to reflect solar radiation efficiently from the body covering. This assumption is substantiated by the researches of many investigators (2, 3, 4, 14, 16, 17, 18, 19, and many others). The early work on this problem has been largely of a semiquantitative nature; a need existed for more detailed study of the physics of absorption and reflection by cattle hair.

The work reported in this paper was therefore undertaken to provide data for calculation of solar-heat load on cattle as an aid to engineering research and practice, and also to clarify a concept in animal physiology.

Animal Heat Transfer and the Solar Spectrum. Fig. 1 illustrates the reduction in solar energy caused by passing through the earth's atmosphere. Little ultraviolet of wave lengths shorter than 290 mμ (millimicrons) is passed. The infrared wave lengths are cut off at about 2μ (microns) (2000 mμ; 20,000 A [Angstrom units]) by atmospheric water vapor. For practical purposes it is assumed that solar energy is transported to the earth's surface in wave lengths ranging from 290 to 2000 mμ, with energy values at each end of this range vanishingly small.

Solar radiation at a given location depends on latitude, time of day, season, altitude, and local atmospheric conditions (12) but its fundamental character differs little from place to place. The wave lengths of solar radiation can be easily reproduced in the laboratory, but the energy distribution cannot. Therefore, it is convenient to study the behavior of material under solar irradiation on the basis of wave lengths.

Some 15 per cent of solar radiation comes from the sky (1). This percentage is evaluated by horizontal surface measurements such as by a flat-plate radiometer (6, 10) or by the Eppley pyrheliometer (5). Sky radiation is due to Tyndall and Rayleigh scattering (21) which alter the solar-energy distribution on earth, but not the involved wave lengths.

Disregarding photochemical effects, an important thermal exchange takes place between an animal and its solar environment. Attempts to quantitatively measure such an environment have only recently been successful with respect to man (15, 20).

The solar heat load on the animal can be partitioned three ways (1): D, direct from the sun to the animal profile; H, reflected from the sky; T, reflected from the earth. The total solar heat load L is then

$$L=D+H+T \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [1]$$

The H load and the T load are delivered to the animal by wave lengths present in the solar spectrum itself. In addition, it is possible to receive significant amounts of H and T energy even when shielded from the D, or direct, energy.

According to Hardy (7) hair and skin at near ordinary body and environmental temperatures behave like black body receivers but only for the corresponding temperature emission wave lengths, 5 to 20 μ in the infrared. The reaction of skin and hair to other wave lengths is here under investigation. Fig. 1 shows that solar energy reaches the earth in the wave lengths of visible and near-visible radiation; therefore, the *pigmentation* of the primary absorption structure, the hair, is of extreme practical importance.

This report presents an attempt to relate hair pigmentation to solar heating on a numerical basis.

Method of Investigation. The problem was approached by measurement of the reflecting power of various types of animal hair. The measurements were made by use of spectrophotometers† having a combined range of wave lengths extending from 290 to 1200 mμ. This region is shown as the shaded area in Fig. 1, and includes about 83 per cent of solar energy for the zenith sun.

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*Numbers in parentheses refer to the appended references.

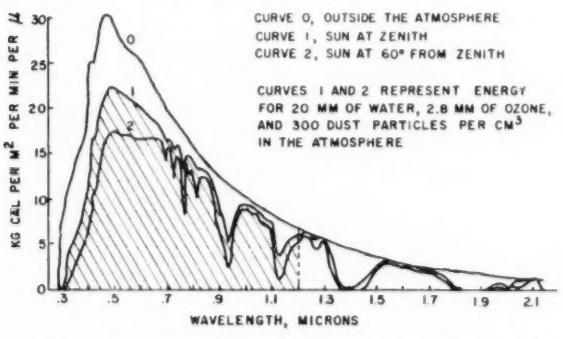

Fig. 1 A typical energy distribution for the solar spectrum under average conditions in the temperate latitudes. The shaded area indicates the range of wave lengths for which the absorption coefficients of various farm animals were measured by spectrophotometric analysis. The approximate visible radiation region is commonly taken to extend from 400 to 700 millimicrons (0.4 to 0.7 microns). The curves are adapted from data of Moon (13)

†Cary Model 11; Beckman Model DU. Refer to Judd (9) for a thorough discussion of spectrophotometer theory and practice.

Samples of hair were taken from representative animals. The samples were arranged in a relatively thick, opaque pad held in position by a cardboard mount (Fig. 2) having a circular opening one inch in diameter. The opening in the mount was applied to the sample ports of the two instruments. The spectral diffuse reflecting power of the hair samples was measured relative to fresh surfaces of magnesium carbonate as a standard, and then corrected for the spectral reflectivity of the $MgCO_3$ itself. The reflectivities thus established can therefore be considered as absolute.

The technique employed, that of removing the hair and then measuring its reflectivity, was shown to be a valid representation of the reflective power in situ (19).

Material objects nearly always absorb, reflect, and transmit selectively. With respect to cattle hide, there are 6000 to 8000 hairs per square inch; therefore, it can be said that transmission is a minimum and can be disregarded. Hence, at a given wave length, λ, 100 per cent of the impinging radiation is disposed of by a combination of reflection and absorption. If we assume that R is the reflected fraction and A the absorbed fraction, then

$$R_\lambda + A_\lambda = 1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [2]$$

for each wave length. By measuring the reflectance, R_λ, for the wave length range from 290 to 1200 mμ and plotting these values against wave length curves are obtained similar to those in Fig. 3. The ordinates, R_λ, are plotted as percentages in Fig. 3 for clarity.

Evidently the total reflectance-wave length function can be written as $R = \int_{290}^{1200} R_\lambda d\lambda \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [3]$

The value R is the area under the typical curves of Fig. 3 for a given animal. To make this value R usable in computation, it is divided by the total area covered by the axes of the graph, thus

$$\text{Reflection coefficient} = \frac{R}{100\ (1200-290)} \quad . \quad [4]$$

The reflection coefficient obtained in this manner is then a dimensionless fraction ranging in value between 0 and 1. By the relation shown in equation [2] we can obtain an *absorption coefficient* by subtracting the reflection coefficient from 1:

$$\text{Absorption coefficient} = 1 - \text{reflection coefficient}$$

The absorption coefficient is defined as a coefficient which expresses the integrated absorptive power of the coat of a given animal with respect to solar radiation of the wave lengths contained in the definite integral of equation [3]. The absorption coefficient must not be confused with emissivity. The hairy coat could never emit in such a range of wave lengths. The absorption coefficient is a dimensionless fractional multiplier to enable one to calculate the percentage of solar radiation which a given animal will absorb when in the presence of such radiation. Clearly, under some conditions, the absorption of such energy must constitute an enormous burden on the animal's temperature-regulation facilities.

A Keuffel and Esser compensating polar planimeter was used to integrate the areas for each animal as expressed by equation [3]. The reflection data were plotted to a rather large scale set of axes to gain sensitivity. The total graph area was 91 sq. in; the value of the reflection coefficient expressed by equation [4] then was: reflection coefficient = area under the reflection-wave length curve (R) in square inches ÷ 91 square inches.

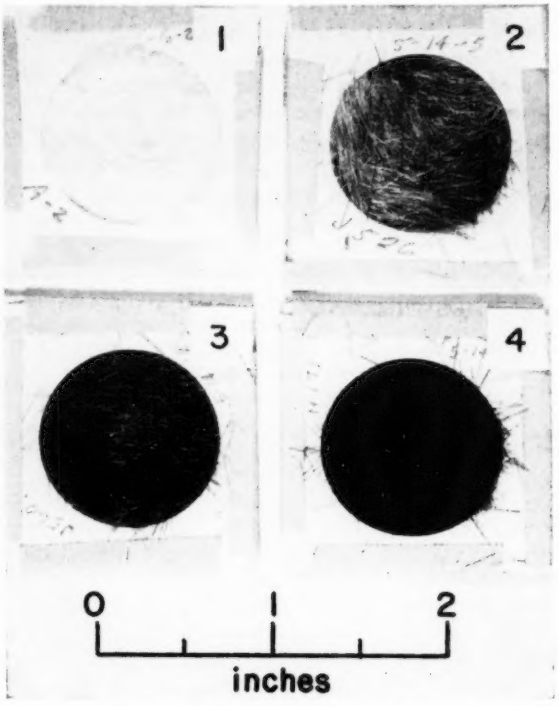

Fig. 2 Photograph of a set of hair samples as mounted for analysis by spectrophotometer. The analysis consisted of determination of the reflectivity percentages at the various wave lengths shown in Fig. 1. The spectrophotometers are arranged so the samples are irradiated by monochromatic radiation, with the reflective power relative to magnesium carbonate measured by the phototube system built into the instruments

Similar methods for obtaining the absorption characteristic were outlined by Blum (1) and more recently by Heer (8).

TABLE 1. SOLAR ABSORPTION COEFFICIENTS OF CATTLE HAIR FOR SOLAR WAVELENGTHS RANGING FROM 290 TO 1200 MILLIMICRONS

(Where Indicated, the Coefficients Apply to Breeds and Colors as Commonly Described)

Breed and color	Solar absorption coefficient
Holstein	
White	0.375 to 0.451*
Black	0.920
Guernsey	
White	0.400
Tan	0.650
Jersey	
Light brown	0.675
Dark brown	0.725
Shorthorn	
Roan	0.672
Dark red	0.778
Hereford	
Light tan	0.645
Medium red	0.760
Very dark red	0.819

*Range of Values indicates presence of dirt to greater or less degree under usual farm conditions.

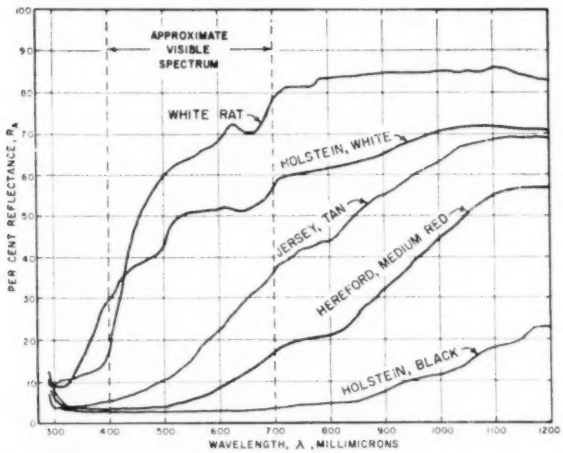

Fig. 3 A set of typical reflectance-wave length curves for the animal hair indicated. Many details relating to securing such curves are given in Stewart et al (19)

Data. The solar absorption coefficients are presented in Table 1 according to breed and apparent color of the cattle. In some cases, particularly the dairy cows, many values of the coefficients were determined for use in another investigation. Where this is true, a median value of coefficient is presented for a given breed and color. The range of such values for a given animal was found to be fairly small, indicating that animal hair is more uniform in color than might be expected.

The reflectance curves in Fig. 3 are presented as typical for the animals indicated thereon. The curve for the albino rat is shown to indicate the extremely efficient reflecting capacity which this white hair possesses. It indicates nearly complete absence of pigment granules.

Discussion and Applications. Measurements of solar radiation absorptivity of animal hairy coats were made by Riemerschmid (16, 17) and Riemerschmid et al (18). Riemerschmidt measurements were made in the open by use of a Moll-Gorczinsky solarimeter (thermopile with glass cover). The most important findings were that color is the most important factor affecting absorptivity for solar radiation; the direction of the hair, its curliness or smoothness, were found to be of secondary importance with respect to absorption.

The Reimerschmid findings were confirmed by the present study. It was found that orientation of the hair, its slickness or curliness, had little or no effect on the characteristic reflectance curve. On the other hand, the sensitive spectrophotometers measured minute differences in *color* of the hair, which the human eye could not perceive.

Reflection (hence absorption) will also depend on the angle of incidence of the radiation. The values reported in this study are all for an angle of incidence of 0 deg. This means the beam of radiation was applied to the sample in a direction normal to the plane of the sample. Greater reflection would take place, with consequent decrease in absorption, as the angle of incidence approaches 90 deg or grazing angle.

Since the values for absorption coefficient reported in Table 1 are for 0 deg angle of incidence, they represent the maximum absorption conditions likely to occur. The animal surface is not flat; the parallel rays of the solar radiation impinge at various angles of incidence on the animal surface. However, the incoming hemispherical sky radiation will impinge on the animal at angles of incidence close to 0 deg with respect to the upper parts of the body.

Estimation of the solar heat load is complex. Many animals, such as the Hereford and the Holstein, present different hair color areas to the solar radiation. Angle of incidence presents difficulty, as previously mentioned. The question of profile area is of great importance; the "quadrants" used by Kelly et al (10) seem to be of definite advantage.

As an example of the utility of the absorption coefficients, consider two 1000-lb dairy animals, one a Jersey of uniform fawn color, the other a Holstein having 60 per cent black and 40 per cent white. According to Brody (3), we estimate the surface area of each animal to be 49.5 sq ft. Let us say that the profile exposed to solar radiation is but 50 per cent of the total, or 24.75 sq ft. Assume that 1 cal per sq cm per min of 290-1200 mμ solar radiation is applied. This is equal to about 221 Btu per sq ft per hr. Assume the following absorption coefficients:

Holstein	
Black areas . .	0.920
White areas . .	0.375
Jersey	0.675

The solar heat load for the Holstein will be

$$221\ [(24.75)\ (0.60)\ (0.920) + (24.75)\ (0.40)\ (0.375)] = 3840 \text{ Btu per hr}$$

and that for the Jersey will be

$$221\ (24.75)\ (0.675) = 3690 \text{ Btu per hr.}$$

With air and surroundings at a temperature near 70 F, the heat production of the animals will approximate 3500 Btu per hr. Thus we see that the superimposed solar heating is actually greater than the metabolic heat itself. This order-of-magnitude calculation indicates the importance of solar heating. Presumably solar heat load could be reduced or nearly eliminated by use of shading as described by Kelly (11). The difficulty of reradiating such a heat load to surroundings at temperatures ranging upwards of 100 F can well be imagined.

The advantage of the Jersey in the above calculations is small, of the order of 4 per cent. However, consider an Angus beef steer of equal weight. In this case the solar heat load might amount to $24.75 \times 221 \times 0.920 = 5030$ Btu per hr, since such an animal would be solid black.

The primary effect of absorbing the solar load on the hair is to heat it. This heating of the hair reduces the thermal gradient from the skin to the hair to the surroundings. Whether or not the reduced thermal gradient is harmful will of course depend on the temperature of the environment. Physical rationalizing indicates that at air and surrounding temperatures of 70 F, or above, animals with low values of solar-absorption coefficient will have considerable temperature-regulation advantage.

ABSTRACT

Spectrophotometric analysis of the reflecting power of hair from a variety of farm animals was made for the wavelength region of 290-1200 mμ. This region includes approximately 83 per cent of solar energy as it reaches the

earth. By use of the reflectance data, a solar-absorption coefficient was derived for the various animals. The coefficients should be useful for calculating the estimated magnitude of solar-heat load on the animals. The fundamental importance of pigmentation of the hair and similar structures is developed, with respect to solar heating. The absorption coefficients are not to be considered as emissivities in the usual sense.

Sample calculations are made to show the use of the coefficients, and to indicate some order-of-magnitude values for the solar heating of typical cattle.

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"Mathematical Analysis of the Offset Slider-Crank Mechanism"

TO THE EDITOR:

IN THE article published under the above title in AGRICULTURAL ENGINEERING for January, 1952 (vol. 33, page 27), the author, Andrew J. Asher, has contributed a method which can eliminate the tedious graphical analysis. However, I wish to point out that errors in differentiation have made both the velocity and acceleration equations erroneous. The equations should read as follows:

$$V_x = \frac{dx}{dt} = \left(-R \sin\theta - \frac{R^2 \cos\theta \sin\theta + hR\cos\theta}{\sqrt{R^2\cos^2\theta - 2hR\sin\theta + K + l^2}}\right)\left(\frac{d\theta}{dt}\right)$$

$$A_x = \frac{d^2x}{dt^2} = \left(-R\sin\theta - \frac{R^2\cos\theta\sin\theta + hR\cos\theta}{\sqrt{R^2\cos^2\theta - 2hR\sin\theta + K + l^2}}\right)\left(\frac{d^2\theta}{dt^2}\right)$$

$$-\left(\frac{d\theta}{dt}\right)^2\left(R\cos\theta + \frac{(R^2\cos\theta\sin\theta + hR\cos\theta)^2}{(R^2\cos^2\theta - 2hR\sin\theta + K + l^2)^{3/2}}\right)$$

$$+\left(\frac{d\theta}{dt}\right)^2\left(\frac{R^2\sin^2\theta - R^2\cos^2\theta + hR\sin\theta}{\sqrt{R^2\cos^2\theta - 2hR\sin\theta + K + l^2}}\right)$$

R. BRUCE HOPKINS
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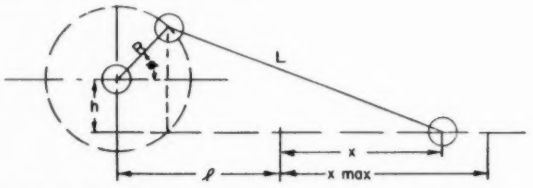


Sketch of the offset slider-crank mechanism: *R*, crankpin radius; *L*, connecting-rod length; θ, angle of displacement with respect to the horizontal; *h*, offset distance of the slider with respect to the crank, and *l*, minimum distance of the slider with respect to the crank measured along the horizontal

Deadlines in Research

THERE are a great many skeptics who wonder what practical good industrial psychiatry can do. Perhaps the best answer is an increase in the efficiency of a research group of 160 people in the Du Pont Company. This increase was due in considerable measure to an experiment in management carried out by a research director in consultation with Dr. F. W. Dershimer (in charge of the industrial psychiatry program of the company).

"There has always been a mistaken idea," Dr. Dershimer says, "that people who are doing creative work cannot work under a deadline. . . . There are several of us who did not think this theory was true. As an experiment, deadlines were put on research projects. A seemingly amazing thing happened. Production in the research group practically doubled. Most of the deadlines in this highly creative field were met, satisfactorily and on time."—*David A. Heller in American Engineer*, for February, 1953.

Drainage as a Tool for Increased Crop Production

Lewis A. Jones
FELLOW ASAE

LAND drainage has been an important factor in the development of agriculture in the United States. It is conservatively estimated that 50 to 60 million acres have been added to the cultivable area in the United States by drainage, and food production has been at least doubled on an additional 60 to 70 million acres. Typical of the areas that have been added are large areas in northwest Ohio, northern Indiana, north central Illinois, north central Iowa, and southeast Missouri, all formerly too wet to be cultivable.

To illustrate what has happened in these areas, I will quote from the report on Long's Expedition to the source of the St. Peters River in 1823, written by W. H. Keating of the University of Pennsylvania who accompanied the expedition. The report was published in 1825. The expedition, undertaken by order of the Hon. J. C. Calhoun, Secretary of War, was made to obtain reliable information concerning the conditions existing in the then undeveloped country lying to the west of Pennsylvania. The St. Peters River, which enters the Mississippi River near St. Paul, Minn., is now known as the Minnesota River. Mr. Keating's description of the land to the east of Ft. Wayne, Ind., is as follows: "Near to this house we passed the state line which divides Ohio from Indiana. . . . The distance from this to Ft. Wayne is 24 miles, without a settlement; the country is so wet that we scarcely saw an acre of land upon which settlement could be made. We traveled for a couple of miles with our horses wading through water, sometimes to the girth. Having found a small patch of esculent grass (which from its color is known here as bluegrass) we attempted to stop and pasture our horses, but this we found impossible on account of the immense swarms of mosquitoes and horse flies, which tormented both horses and riders in a manner that excluded all possibility of rest." His description of the land south and west of Chicago is also interesting: "From Chicago to a place where we forded the Des Plaines river the country presents a low, flat, and swampy prairie, very thickly covered with high grass, aquatic plants, and among others the wild rice. The latter occurs principally in places which are under water; its blades floating on the surface of the fluid like those of the young domestic plant. The whole of this tract is overflowed during the spring, and canoes pass in every direction across the prairie."

One traveling over these same areas today and noting the well-cared-for productive fields, the substantial and attractive farm buildings, the good roads, and splendid school buildings, does not as a rule recall that all of these developments have been made possible by drainage — that if such work had not been done, the areas still would be in much the same condition described by Mr. Keating in 1823. In both areas there are now more miles of public outlet ditches and drains than there are miles of public highways.

In discussing the place of drainage as a tool in agricultural production, it seems desirable to outline briefly the history of such work in the United States.

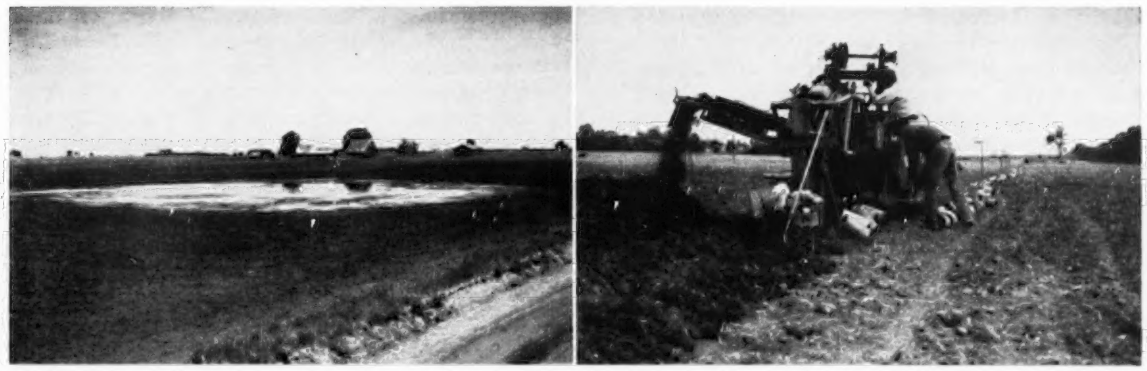
Early Drainage. Drainage of farm lands began in each of the colonies soon after the first settlement was made. The work consisted primarily of constructing small open ditches to drain wet spots in fields, and in cleaning out small natural streams. Little engineering work was involved. In 1835, John Johnson of Seneca County, New York, brought over from Scotland patterns from which clay tile were moulded by hand and laid on his farm near Geneva. This can be considered the start of modern tile drainage in the United States.

The settlement of the Ohio and Mississippi valleys was just starting. Much of this land, though very fertile, could not be cultivated until it was drained, and malaria was prevalent in large areas. The use of tile spread rapidly until, by 1880, there were 1,140 factories in operation, located principally in Ohio, Indiana, and Illinois. By May, 1882, 30,619 miles of tile had been laid in Indiana, with one county not included in the statistics.

The sizes of tile manufactured increased steadily, and in the early 80's some plants were able to make 24-in tile.

An address before the meeting of the American Society of Agricultural Engineers held in conjunction with the Centennial of Engineering Convocation at Chicago, Ill., September, 1952.

The author — LEWIS A. JONES — is chief, division of drainage and water control, Soil Conservation Service (Research), U.S. Department of Agriculture.



(Left) This picture is typical of low, wet spots in many cultivated fields on American farms that could be corrected by proper drainage methods, preferably by tile • *(Right)* This Buckeye ditcher is digging a trench for a 6-in line of draintile on a farm in Illinois. The owner installed 4580 ft of tile to reclaim and make tillable about 12 acres of land. (S.C.S. photo)

The sizes used in farm laterals increased gradually, until at the present time nothing smaller than 4 in in diameter is used; and in large sections of the Middle West, 5-in tile is considered the minimum size.

The problem of computing the carrying capacity of draintile received serious consideration by the early drainage engineers. Poncelet's formula was generally used. In 1916-17, Yarnell conducted extensive experiments and developed a formula for the flow in draintile that is now in general use.

The hand tools used in constructing drains underwent much improvement during the period 1840 to 1880. About 1873, Manley Miles invented the present type of drain scoop which made the finishing of the bottom of the trench to grade much easier. The skeleton spade was also invented during this period.

As the size of tiles and depths of drains increased, a demand developed for a machine that would dig trenches. In 1869 the Rennie elevator ditcher, which was operated by horses, was patented. By 1880 seven kinds of horse-powered machines were on the market. In 1883 the Plumb ditching machine, powered by a steam engine, was placed on the market. Shortly after this several other steam-operated machines were being made. From these our modern, efficient tile-trenching machines were developed.

Open Ditches. It early became apparent that, if many tile-drainage systems were to be successful, large outlet ditches must be provided. To begin with, these were constructed either by hand or with teams and scrapers. Usually they were not more than 5 ft deep, the bottom width only occasionally exceeding 4 ft. The construction of such outlet ditches increased rapidly as the north central states were settled. In 1884 the drainage committee of the Ohio Society of Engineers and Surveyors reported that in Ohio 20,000 miles of county and township ditches had been constructed, benefiting 11,000,000 acres of land. The report placed much emphasis on the benefit these drains had been to the health of the state. However, most of these ditches were found to be too small to provide the degree of drainage desired. There was need for an economical means of constructing large open ditches.

Floating Dredge. In 1882 the Mason and Tazewell Special Drainage District was organized in Mason and Tazewell Counties, Ill., with Herbert Hamilton of Petersburg, Ill., as engineer. The drainage plan comprised a main ditch 14½ miles long, 10 ft deep, varying in top width from 30 to 60 ft, with side slopes of 1 to 1; 37 miles of lateral ditches 10 ft deep, and 30 miles of scraper ditch. Mr. Hamilton conceived the idea of developing a dipper-type dredge for use on this project, patterned after dredges then used in digging navigation canals. Five such dredges were constructed by the Bucyrus Foundry and Machinery Co. of Bucyrus, Ohio, and used by the contractor, W. A. McGillis and Co. This was the first drainage district on which dredges were used, and the main ditch, when constructed, was the largest in the United States. *Engineering News* in commenting on the work stated: "This was the first work done with dredge, and has been so satisfactory that it may be said to have worked a revolution in such matters."

For the next 25 or 30 years there was a gradual improvement in the design of dredges. Improved power plants were developed. The vertical spud was replaced by the bank spud, which permitted the use of a narrower hull, thus enabling the machine to dig smaller ditches. On the other hand, the design of larger and larger ditches led to the design of larger dredges, until by 1910 floating dredges ranged in size from the small ½-yd machine with 25 or 30-ft boom, to the 5-yd machine with a 100 to 125-ft boom.

Dragline Excavators. In 1903, Page and Schnable built the first dragline excavator for use in constructing the Hennepin Canal. This type of excavator was first used on drainage ditches in 1906, and by 1920 had practically replaced the floating-dipper dredge on drainage work. In the early days various methods of moving the machine were used, but during recent years practically all draglines have been mounted on wide-tread, track-type tracks.

The great advantage of the dragline excavator over other types is its flexibility. There are well-defined limits to the size of ditch that can be constructed by floating-dipper dredges of a given size, but such limits do not apply so closely to the dragline. It has the advantage that on large ditches it can leave a wider and cleaner berm than is possible with a dipper dredge.

Pumping for Drainage. The use of drainage wheels, operated by animal power, to drain low land was early practiced among the plantations of the Gulf Coast, especially in the area devoted to the growing of sugar cane. About 1850, pumps began to be used, especially designed for low-lift pumping. In the late 1860's the Ivens pump was invented, followed in 1880 by the Menge pump which was widely used on small projects.

As the projects became larger, low-lift centrifugal pumps gradually supplanted other types. In 1915 the Wood screw pump was developed and is now widely used on the larger pumping projects.

Pumping was first introduced in the bottom lands lying along the Illinois River about 1909. At present practically all Illinois River bottom land is drained by pumps, as well as a large part of the bottom land along the Upper Mississippi River in Missouri, Illinois, and Iowa.

According to the 1950 Census, there are 378 drainage enterprises, equipped with pumps furnishing outlets for about 1,700,000 acres, and having a pumping capacity of 20 million gallons per minute.

Drainage of Irrigated Land. Soon after irrigation started in the West, some of the land began to be damaged by seepage and the accumulation of alkalies. By 1902 the situation had become so serious that the Department of Agriculture employed an engineer to work with landowners on the problem. He found that shallow drains, such as are used in humid areas, were ineffective but that a deep drain, properly located, would drain an entire field. Through the years, requirements for the drainage of irrigated land have been developed. At the present time, on new projects, the general practice is to develop drainage plans at the same time as the irrigation plans and not as an afterthought, when seepage and alkali problems have developed.

Extent of Drainage Works. According to the Census Bureau, there are 103 million acres in organized drainage enterprises in which more than 894 million dollars have been expended on public drainage improvements. With the 894 million dollars, more than 155,000 miles of outlet ditches, 56,000 miles of main outlet tile drains, 7,800 miles of levees, and 110,000 hp of pumping plants have been constructed.

Of the 103 million acres in drainage enterprises, some 15 million acres are still too wet for cultivation, and crop

losses are frequent on an additional 10 million acres, due to poor drainage. These unsatisfactory conditions are due primarily to lack of sound engineering in designing the improvements, and to poor maintenance.

There is no reliable record as to the amount of money spent nor the number of miles of field ditches and tile drains that individual farmers have installed on field drainage. Those acquainted with such work estimate the expenditure at many times the amount expended on outlet drainage. It is sad to relate that much of the money has been wasted due to lack of engineering guidance.

Results of Agricultural Drainage. The drainage conditions existing in northwestern Ohio and northeastern Indiana in 1825 have already been described. Eleven counties are included in the area which was originally low, swampy land, impossible to cultivate. As a result of drainage this area is now one of the most productive areas in the country and according to the 1950 Census produced 198 million dollars worth of agricultural products in 1949. Few people realize that several of the counties in the area have more miles of public outlet ditches than they have public roads, not to mention the hundreds of miles of field ditches and tile drains that have been installed by the individual farmer.

In north central Iowa there are extensive areas of flat land comprising about 90 per cent of seven of Iowa's richest agricultural counties. Prior to settlement, the greater part of the land was in shallow sloughs that remained wet so much of the time they could not be cultivated at all. The rest of the area was subject to cultivation but crop yields were generally low and frequently failed altogether, due to lack of drainage outlets. Drainage work was started soon after settlement and today this extensive area is all included in drainage enterprises and has been provided with drainage outlets. The Agricultural Census for 1950 shows that the value of agricultural products raised in the area totaled 128 million dollars for the year 1949. At least 75 percent of this production would not have been possible without drainage.

In southeast Missouri there is one drainage district of 400,000 acres that covers the greater part of four counties. This district, with other smaller districts, covers practically the entire area of five counties. In 1909, prior to drainage, the only land in the area under cultivation was located in small patches along the banks of some of the streams. Less than 5 per cent was cultivated. The balance was swamp land. Drainage work was started about 1912, and now 95 per cent of the area is under cultivation and comprises some of the most valuable land in Missouri. According to the Agricultural Census, the value of agricultural products produced in the area in 1949 amounted to 76 million dollars.

I could continue to give similar examples of outstanding benefits resulting from drainage work. Large areas in western Minnesota, central Illinois, northeast Arkansas, the Gulf Coast of Texas, and the delta areas in Mississippi and Louisiana were originally swamp and overflow areas, and would not now be under cultivation except for drainage.

The results of drainage outlined above should be sufficient answer to over-enthusiastic sportsmen and nature lovers who vociferously proclaim that drainage is entirely unjustified, is ruining the country, and destroying wildlife. The public has had drainage held up to it as a crime committed in the name of development. True, some mistakes have been made. Land has been drained that is of no value to agriculture, and has been ruined for wildlife. In other areas the plan of drainage proved unsatisfactory, with the result that it was largely ruined for wildlife and was of little or no value for agriculture. In some places no provisions were made to control sediment and within a year or so the drainage improvements were destroyed.

The total area of ill-advised projects does not exceed 5 per cent of the total and practically all of such projects were undertaken 30 to 40 years ago. The area of ill-advised projects undertaken since 1920 does not exceed one per cent of the area in drainage enterprises. In view of the wide benefits to the agricultural development of the country that has resulted from drainage activities, it would appear that those interested in nature and wildlife would serve the country better if they would cooperate with agriculturalists, foresters, and engineers in determining whether a sound national program of conservation and agricultural development indicates that certain types of drainage work are desirable, instead of uncompromisingly opposing all drainage work. Certainly the history of drainage shows that most of it has been desirable; that, but for drainage, much of our

(Left) About 8,000 acres are involved in the reconstruction of this large drainage ditch. The dragline shown is removing the dirt and spreading it on the berm at a cost of 18 cents per cubic yard • *(Right)* A drainage ditch in South Carolina excavated with a dragline. (S.C.S. photo)

most productive agricultural land would still be in swamps or too wet to cultivate.

Importance of Maintenance. One of the most important problems facing drainage engineers today is the problem of developing economical methods of maintaining drainage improvements after they have been constructed. The first requirement of an adequate drainage system is proper design and construction. A well-designed system will provide for prompt disposal of excess soil water, and will be constructed so as to facilitate maintenance work. The second requirement is a systematic and continuing program of maintenance.

The division with which I am connected has done a considerable amount of work relating to maintenance of drainage ditches. We have found that one year's growth of vegetation will reduce ditch capacity by as much as 50 per cent. In two or three years, without maintenance, the capacity of many ditches is reduced to but 20 or 25 per cent of their original capacity because of vegetative growth.

Sedimentation is another serious problem. Soil is washed into a ditch from an eroding watershed, from a lateral drain with an unprotected inlet, or from an unprotected ditch bank. Occasionally silt is deposited in ditches due to decreased velocity of water resulting from the flattening of the ditch grade. In some instances, trouble is due to poor design and to failure to control erosion on the surrounding watershed, but most frequently it is due to failure to maintain the drainage improvements themselves.

Early drainage improvements were designed with little or no regard for maintenance problems. During the past 20 years engineers have come to realize the importance of such work. In rehabilitating existing projects and in planning new work, consideration is now generally given to maintenance requirements. Ditch cross sections are designed to facilitate the operation of equipment to control vegetation and remove silt. Ditch berms are made wide enough to permit the operation of such equipment along the ditch banks. Outlets of laterals are constructed to control or reduce sediment deposits in outlet ditches. Erosion-control practices are being installed on watersheds to reduce sedimentation in ditches.

During the last five years a number of experiments have been conducted on the use of chemicals in controlling vegetative growth in ditches. The problem is complicated by the fact that both water plants and land plants are involved. Considerable progress has been made in determining chemicals and combinations of chemicals that are effective in controlling certain types of plants. However, additional work is required both with the chemicals and with methods of application before specific practices can be recommended for general use.

Future Developments in Drainage. Future drainage developments are closely allied with the agricultural production job which faces the country. The population of the United States increased from 131.7 to 151.8 millions in the 10 years from 1940 to 1950, and is continuing to increase at the rate of about 2 million a year. There has been an increase in per-capita food consumption of about 12 per cent since 1940 due in large part to expanding consumer purchasing power. In 1951 we consumed more than we produced in 1950, and it appears that demands for 1952 will exceed 1951 production.

With population increase alone—2 million more to feed each year—farm output simply must continue mounting if we are to maintain our present standard of living. It is estimated that by 1975 the demand for agricultural products will be 20 to 25 per cent greater than our current production. This does not mean that our country is going to run short of food in the foreseeable future. During the decade to 1950 we increased our farm output by more than 25 per cent, with only a 3 per cent increase in crop acreage. There is no reason to suppose that a similar increase cannot be made in the next decade. Studies indicate that average per-acre crop yields for most crops can be increased 50 per cent or more if all the technology now available is put to work. For instance, experienced soils men estimate that about 20 per cent of the cultivated land in the humid section of the United States would be benefited by improved drainage. Results obtained in draining such land show crop increases averaging about 50 per cent. Based on the foregoing, it seems there are some 30 to 40 million acres of land now under cultivation on which crop yields can be materially increased by drainage. Such increase can be obtained without the use of any additional seed, fertilizer, farming equipment, or labor. Such work is worth thinking about. It should be high-priority work.

Another factor bearing upon the ultimate capacity of the country's agricultural plant is the 12 or 15 million acres of undeveloped land in organized drainage enterprises, which although partially drained is still too wet to cultivate. Additional drainage facilities will have to be provided before this land can be developed for agricultural use. The cost of such work will be low, but a good deal of the land is cutover timber land and the cost of development after it has been drained must be taken into consideration.

In addition to the land in organized drainage enterprises, there still remains about 100 million acres of swamp land in the country. This land is distributed throughout the humid sections of the country, in areas ranging in size from 500 to 1,000 acres to several hundred thousand acres.

It is estimated that about 20 million acres of these 100 million acres are suitable for agricultural development. At present they can be considered as a reserve available to expand our agricultural plant when needed. The development of this land should only be undertaken after thorough consideration has been given to other possible uses, such as wildlife habitats, recreational areas, and the growth of forests. In some instances the land may be worth more to the nation in one of these uses than in cultivation. The important thing is that the land be put to the use that will be of greatest value to the country.

The remaining 80 million acres of these 100 million acres are so situated or have such poor soils that they are not desirable for agricultural development. They are available for wildlife habitats or recreational areas and should be developed for such uses.

CONCLUSION

In conclusion, it can be stated that drainage is an effective tool for increased crop production. To receive full benefit from existing drainage works, they must be rehabilitated, where necessary, and an effective program of maintenance initiated. In some instances, additional public ditches are required to serve as outlets. The principal need is to improve field and lateral *(Continued on page 250)*

The Basic Concepts of Prestressed Concrete

Maurice L. Burgener
ASSOC. MEMBER ASAE

PRESTRESSED concrete is new to this country but its use is spreading rapidly. It was not until 1949 that the first major prestressed concrete structure using linear prestressing was built in the United States. This was the Walnut Lane Bridge in Philadelphia. Already, only 3 years later, there are over 100 major structures in this country which are built of prestressed concrete.

Although the application is new, the principle of prestressing is old. The first patent on the idea was issued in 1888 to a San Franciscoan. In 1923 and 1925 additional patents were granted to R. H. Dill of Alexandria, Nebr., but the idea didn't develop further at that time primarily because of the limitations on the kind of reinforcement that was used. It is of interest to agricultural engineers that Mr. Dill applied the principle of prestressing to a simple agricultural item — concrete fence posts.

Subsequent to these early patents, European engineers took the initiative and developed the idea further. Prestressed concrete construction grew rapidly there until it now occupies a position of prominence in the structural field. It has been used for highway and railroad bridges, industrial buildings, precast joists, pressure pipe, poles, piling, water tanks and many other uses.

What is Prestressed Concrete? Visualize a beam built of concrete in which no tensile stresses exist, a beam that has great spring or elasticity and perfect homogeneity, a beam that is crackless under design loads. Imagine a concrete beam that, if overloaded, will crack and bend excessively to show its overload, but when the load is removed will return to its initial shape. That is prestressed concrete.

How are these remarkable properties obtained? Merely by compressing the concrete prior to the application of the working load. As the concrete is compressed, internal stresses are set up within the material. These internal compressive stresses counteract the tensile stresses that are later induced by the working load. Perhaps a better name for the material might have been precompressed concrete.

WHY PRESTRESSED CONCRETE?

The answer to this question is threefold; prestressed concrete offers (1) properties that can aid the engineer in building better structures, (2) a chance to conserve vital materials, and (3) opportunities for economical construction.

A Better Structure. Concerning the building of better structures, the old saying, "Build a better mousetrap and the world will beat a path to your door," is especially apropos. Prestressed concrete gives the engineer a material which has improved structural properties that should help him build better structures. The improved properties made possible by prestressing are:

1 The concrete is made crackless, which is conducive to greater durability under severe conditions of exposure.

2 The depths of beams and girders and the thickness of slabs can be reduced, thus affording more headroom.

3 High-strength concrete of correspondingly better quality can be used most efficiently.

4 Under *working load* prestressed members are rigid and stiff, but under *overload* members give warning by maximum deflection.

5 Prestressing makes it possible to use thin web members of I and T sections, thereby using materials most efficiently.

6 Prestressing results in a homogeneous beam with its characteristic ease of designing.

It is not inferred that prestressed concrete should be used indiscriminately and that no matter where used it will result in a better structure. Rather, prestressed concrete should be considered as a new tool in the engineer's kit. It is a tool that we know has advantages for some jobs, but perhaps may not be as good as the old tools for others. Because of its newness we do not yet know all of its uses, but engineering ingenuity will develop those uses as the basic characteristics of the material become more universally known.

Material Savings. The savings of material made possible by prestressing is impressive. Up to 50 per cent of the concrete and 75 per cent of the steel over that used in a conventionally reinforced structure can be saved by prestressing. Savings of this magnitude cannot long be ignored. In addition to monetary value, such material savings aid markedly in conserving our natural resources. This is particularly important in time of national emergency when quantities of building materials are often limited.

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1952, as a contribution of the Farm Structures Division.

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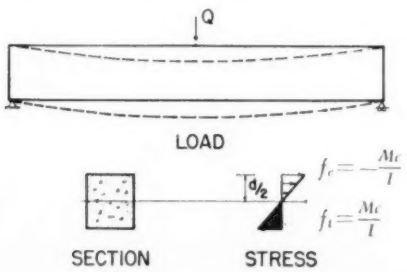


Fig. 1 Plain concrete beam

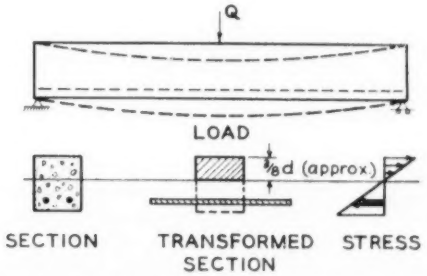


Fig. 2 Reinforced concrete beam

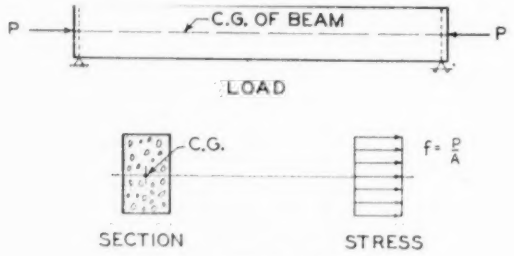


Fig. 3 Prestress load only

Economy. The acid test of any new material is cost. Cost comparisons in this country are limited, but European experience has shown that prestressed concrete is definitely competitive with other materials there. In a fair analysis, however, it must be recognized that European building materials are often scarce and costly, while labor is abundant and cheap. Such conditions do not exist here.

It would not have been unexpected if early American experience had shown prestressed concrete to be more expensive than conventional construction. Engineers, when dealing with a new material, are inclined to be especially conservative and quite properly so. Contractors, when asked to bid on an unfamiliar type of construction, tend to bid higher because of their unfamiliarity with it. In spite of these handicaps, most of the structures thus far built in this country by prestressing were bid at equal or lower cost than other types of construction considered for the same location.

BASIC CONCEPTS OF PRESTRESSED CONCRETE

The basic ideas of prestressed concrete can best be explained by starting with a material universally known — plain concrete. For simplification, throughout the following discussion a weightless beam will be assumed and the beam to be investigated at the region of maximum bending.

If a rectangular beam of plain concrete is cast and loaded in bending, it will tend to deflect as shown by the dotted lines in Fig. 1. That deflection will cause the top fibers of the beam to compress and the bottom fibers to stretch. A plane will exist at the center of the beam cross-section where the stress is equal to zero. This stress distribution will be as shown; the area above the line represents compression and the area below represents tension. Since this is a homogeneous beam the magnitude of the extreme fiber stresses can be evaluated by the familiar bending formula $f = Mc/I$. It should be noted that from similar triangles the extreme compressive stress f_c is equal to the extreme tensile stress, f_t. But

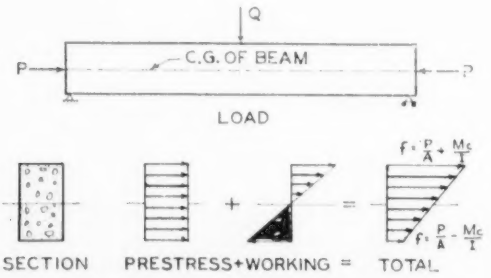


Fig. 5 Combined load

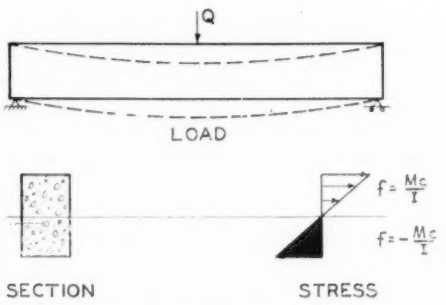


Fig. 4 Working load only

concrete can carry roughly ten times more compression than tension. Therefore, nine-tenths of the compressive strength is being thrown away in a plain concrete beam because of its tensile weakness.

When engineers learned to place steel rods in flexural members at the locations where tensile stresses developed, they made reinforced concrete a material that will carry infinitely more load in bending than plain concrete. Fig. 2 shows the same beam, as in Fig. 1, with reinforcing steel added. In reinforced concrete design, the concrete is not credited with any tension and all the tensile forces must be carried by the steel. This results in a non-homogeneous or two-material beam and the necessity of using a transformed section for design purposes. It can be shown that the plane of zero stress moves upward from the midpoint of the section that it occupied in a plain concrete beam, to a point about three-eighths the beam depth below the top face. The bending load Q will again cause the beam to deflect as shown by the dotted line, and will cause the stress distribution shown. Only three-eighths of the beam depth will be in compression and only the steel will be in tension. Therefore, the lower five-eighths of the beam increases the dead load without adding to the bending resistance of the beam. Furthermore, as the reinforcing steel stretches, the concrete cannot follow this elongation and minute cracks form along the bottom face of the beam. These cracks do not impair the load-carrying ability of the beam but do show again the tensile weakness of concrete.

Now about prestressed concrete. If the plain concrete beam of Fig. 1 is compressed by adding the axial load P, which acts at the center of gravity of the beam, then the beam is prestressed. The prestress force causes the beam to shorten as shown by the dotted lines in Fig. 3.

This creates compressive stresses which may be evaluated by the simple formula, $f = P/A$. Since the beam is

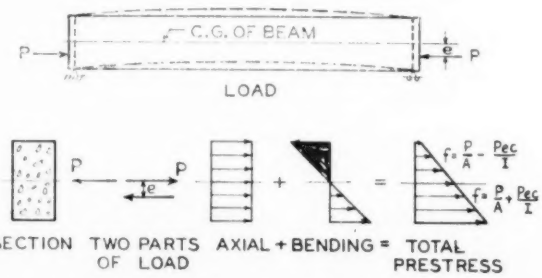


Fig. 6 Prestress load only

once again homogeneous, the lateral load Q causes a stress distribution of the same pattern as it did in Fig. 1, that is, compression in the top fibers and tension in the bottom fibers (Fig. 4). The magnitudes of the extreme tensile and compressive stress will be equal and can be evaluated by the flexural formula $f = Mc/I$. When both the axial load P and the working load Q are acting, the resultant stress will merely be the algebraic sum of the stresses produced by the two loads acting independently. Thus under working load the stress in the top fiber is $P/A + Mc/I$ and the stress in the bottom fiber is $P/A - Mc/I$ as shown in Fig. 5. It can be seen that now the whole depth of the beam is effective in resisting load and that no tensile stresses are developed within the beam. Thus the concrete is used much more efficiently than it was either as plain concrete or as ordinary reinforced concrete. After studying the above relationship of stresses, it soon becomes apparent that the load Q will be limited by the compressive strength of the top fiber of concrete. For as Q increases, the moment M increases and both the tensile and compressive stresses Mc/I increase. In order to maintain a tensionless crackproof beam the axial load P must be increased.

If by prestressing compressive stresses could be induced in the bottom fiber without adding compressive stresses in the top fiber, the load-carrying ability of the prestressed beam could be increased. This is done in Fig. 6. The prestress load P, instead of being placed at the center of gravity of the section as it was in Fig. 3, has been applied at a distance e below the center of gravity. This force causes the beam to compress and also to deflect upward as shown by the dotted lines in Fig. 6. Another way of explaining this is that the eccentric force P can be replaced by the axial load P and a couple Pe.

Thus the stress induced by the prestress force includes two parts — one part due to the axial load, the other part due to the moment Pe. These two parts may be evaluated respectively by the axial load formula $f = P/A$ and the bending formula $f = Mc/I$. Since $Pe = M$, the latter term becomes $f = Pec/I$ and this is a tensile stress in the top fibers but a compressive stress in the bottom fibers. The combined effect of the eccentric prestress load is therefore shown in the third stress diagram where the stress in the top fiber equals $P/A - Pec/I$, and the stress in the bottom fiber equals $P/A + Pec/I$. The beam is entirely in compression with no tension.

Considering the effect of the working load Q by itself, the stress distribution will be compression in the top fiber and tension in the bottom as it was in the previous example (Fig. 4). Under actual loading conditions both prestress and working loads will be acting and the combined stress will be as shown in Fig. 7, all compression and no tension. The magnitude of the stress in the top fiber will be $P/A - Pec/I + Mc/I$ and in the bottom fiber will be $P/A + Pec/I - Mc/I$.

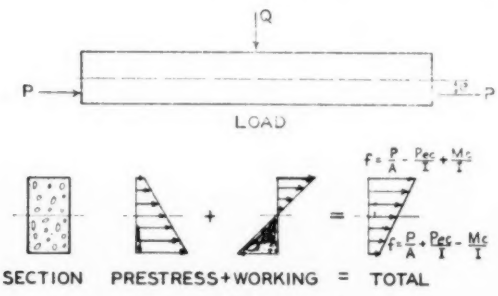


Fig. 7 Combined load

Now what has been accomplished by prestressing? First, the concrete has been made to act entirely in compression — the property in which it is strongest. Second, the entire beam section has been made active in carrying loads thus making it possible to use shallower members for any specified load. And, third, by adjusting the application point of the prestress force, the load-carrying ability of the beam has been increased. This third point has still greater potentialities, namely, that by lowering the point of application of the prestress force dead-load stresses may be overcome and a "weightless" beam results. This is especially important on long-span construction where much of the beam strength is ordinarily required to carry dead load.

Other investigations are necessary in the complete design problem, but they will not be discussed here. A rectangular section is not the most economical. It was used here merely for the sake of simplicity. An I or T section will give much more economical use of materials.

APPLICATION OF PRESTRESS FORCE

The prestress force is applied by stretching the reinforcement. There are two general methods of doing this. One method is called pretensioning, the other posttensioning. The terms describe the time at which the steel is tensioned in relation to the time of casting the concrete.

Pretensioning. In pretensioning, steel wires are stretched in the form prior to placing the concrete. Concrete is then cast and allowed to harden, after which the wires are released from their outside anchorage. As the wires contract after release of load they transmit compressive stresses to the concrete by bond. This requires use of small wires, usually under ¼ in diameter, to keep bond stresses within permissible limits.

Posttensioning. In posttensioning, the concrete is cast first and allowed to harden. Openings are cast in the concrete the length of the beam through which the steel is strung. By mechanical means the steel is anchored to one end of the beam. At the other end jacks are used to stretch the steel and then it is anchored with a mechanical anchor at that end. Large diameter rods or bridge cables may be used since the mechanical anchor is relied on to hold the tension and bond to the concrete is not essential.

KIND OF MATERIAL NEEDED

As indicated earlier, the basic idea of prestressed concrete was known as much as 65 years ago, yet when the idea was tried under various conditions it did not work. About 20 years ago a French engineer, Freyssinet, recognized the trouble. He used high-tensile-strength wire instead of the usual mild steel reinforcement and overcame the main obstacle.

As we look back now, the reason for using high tensile-strength steel is painfully logical. Concrete shrinks during the hardening process. Also, under sustained compression concrete shortens even further or "creeps". To a lesser extent, steel tends to lengthen somewhat under sustained tension. All of these volume changes *(Continued on page 250)*

Sprinkler vs. Gravity Irrigation — A Basis for Choice of the Best Systems

Fred B. Hamilton and John F. Schrunk
MEMBER ASAE MEMBER ASAE

SOME characteristics of sprinkler and gravity irrigation systems under the conditions prevailing in the Great Plains States will be examined in this paper and a basis for choice of the best system suggested for an individual farm. Differences of opinion exist regarding the relative advantages of sprinkler and gravity irrigation, and the extent to which sprinkling will eventually replace gravity types. Some of the problems which must be considered in making a choice are initial investment, operating and maintenance costs, irrigation efficiency, and, in some cases, the personal traits of the irrigator.

Certain geographical features of the Great Plains states such as topography, soils, wind, and amount of rainfall have a pronounced effect upon the choice of an irrigation method. The topography of the area is predominantly level to gently rolling. This topography together with the frequent occurrence of deep, medium-textured soils makes the land preparation required for gravity irrigation more feasible than in many other areas. Wind velocities on the plains are high and variable. Average rainfall ranges from 12 to 30 in. annually. The irrigation requirements increase as the rainfall decreases. As a consequence, the total irrigating cost is relatively more dependent upon operating costs than upon initial investment. All of these factors should be kept in mind in making a choice between sprinkler and gravity irrigation.

Two assumptions seem necessary to a reasonable comparison of these methods of water application. First, it is assumed that both systems should be designed according to adequate engineering standards. The second assumption, which is dependent upon the first, is that a major investment would be required for the proper installation of either a gravity or sprinkler system. On the basis of these assumptions, the characteristics of both systems properly installed and operated will be investigated.

FIRST COST AND DEPRECIATION

No general statements can be made regarding the probable relationship of the first cost for the two systems. Several surveys have been made which give initial costs of sprinkler systems (7, 10)*. The Bureau of Reclamation, USDI, gives examples of comparative costs in their publication on sprinkler irrigation (3). Comparative first costs must be estimated for each case. Such costs can be estimated closely by making a study of the particular farm on the basis of the items listed in Table 1.

TABLE 1. ITEMS INCLUDED IN INITIAL INVESTMENT FOR AN IRRIGATION SYSTEM

GRAVITY	SPRINKLER
Water supply	Water Supply
Land Preparation	
Conveyance Systems:	Conveyance Systems (Mains):
Open ditches	Open ditches
Closed conduits	Closed conduits
Drops, division boxes	
Distribution Systems:	Distribution Systems:
Checks	Sprinkler laterals — complete
Spiles, siphons or both	Pump
Gated pipe	
Machinery:	Machinery:
Floats	For moving pipe
Ditchers	

Calculation of depreciation on the initial investment should be handled somewhat differently for the two systems. A good land-grading job does not depreciate if the soil is properly managed. Maintenance is required, but the initial earth-moving operation will not need to be repeated. In connection with the gravity system there will be depreciation on conveyance equipment, structures, and distribution equipment. Ditches may either be depreciated or considered as an annual cost depending on the practice followed on the individual farm. The depreciation on mechanical equipment can be calculated on the probable life of the major parts of the system. Depreciation periods are suggested in Table 2 subject to modification to fit local conditions.

TABLE 2. SUGGESTED DEPRECIATION PERIOD FOR COMPONENTS OF AN IRRIGATION SYSTEM

GRAVITY	SPRINKLER	DEPRECIATION PERIOD YEARS
Well	Well	25
Pumping equipment	Pumping equipment	15
Farm ditches (perm.)	Farm ditches (perm.)	20
Concrete structures		20
Pipe	Pipe	15
Misc. control equipment	Sprinkler laterals	15
Power units	Power units	
Combustion	Combustion	10
Electric	Electric	25
Land grading		None

OPERATION AND MAINTENANCE COSTS

The cost of all operations incident to irrigation must be segregated from cultural operations and charged to the irrigation system. The labor requirements of a gravity system for laying and operating a surface pipe or for distributing water from a ditch are estimated on the basis of field arrangement, crops and equipment used. The amount of labor required for distribution of water and the degree of skill required of that labor progressively decrease with increased refinement of land preparation.

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Kansas City, Mo., June, 1952, as a contribution of the Soil and Water Division. Published with the approval of the Director as Paper No. 592, Journal Series, Nebraska Agricultural Experiment Station.

The authors — FRED B. HAMILTON and JOHN F. SCHRUNK — are, respectively, irrigation engineer, Soil Conservation Service (Research), USDA, and agricultural engineer, Nebraska Agricultural Experiment Station.

*Numbers in parentheses refer to the appended references.

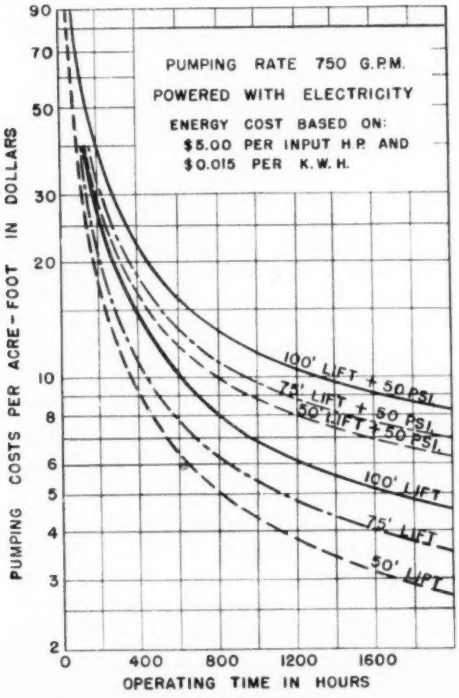
The construction and filling of annual field ditches should be shown as an operational cost. The cost of bordering and corrugating should be charged according to the expected years of use. Furrowing requires additional operations with most crops. The e and similar items are properly charged as irrigation costs.

The maintenance of the land-preparation job must be given consideration in calculating costs. Floating is necessary to correct the effects of tillage on the land surface and should be considered as a maintenance operation. To illustrate this type of cost the following example is presented concerning the preparation of an 18-acre field for border dike irrigation. A light disking and packing operation would have provided a satisfactory seedbed. However, 30 hr. were spent in floating to correct minor surface irregularities. This operation required 1.7 hr. per acre and would be repeated every 1 to 5 years, depending on the rotation. Such charges should be made against the irrigation system rather than seedbed preparation.

Operating cost is affected by both the total irrigation water required, and by the number of applications necessary. Irrigation requirements, if not known, can be computed by the procedure suggested by Blaney and Criddle (2). Depth of water applied per irrigation is dependent on the rooting habits of the crop and the water-storage capacity of the soil. This depth of application in turn will determine the number of irrigations. Water cost is dependent on seasonal irrigation requirements while labor cost is proportional to the number of applications necessary.

The proper evaluation of operation and maintenance costs for surface irrigation can be made on the basis of these considerations as follows:

1 Refinement of land grading as reflected in labor requirements



Pumping costs from Nebraska field study

2 Maintenance and labor requirements of the conveyance and distribution system

3 Seasonal irrigation requirements

4 Number of irrigations.

Operating and maintenance costs for a sprinkler system include the consideration of similar items, along with power requirements for increased pressure. The costs of maintenance will be dependent on the quality of water pumped, the total hours of use, and the care with which the system is handled. A common example of misuse causing excessive maintenance is the introduction of soil into the system by carelessness in moving and coupling the laterals. The cost of maintenance has been found in separate surveys to vary from 30c to $3 per acre (3, 10).

The labor required for operating a sprinkler system has often been considered as a chore. As such, the operation carries with it all the stigma of a "chore" and comes more and more into disfavor. During the 1952 season pipe-moving labor requirement studies were conducted by the Nebraska Agricultural Experiment Station. Time requirements were observed for moving, reassembling and flushing of sprinkler laterals. Although the time required varied greatly, the average requirement was 0.83 man-hours per acre for moving 4-in. pipe.

The moving techniques generally used by the farmers were as follows:

1 Two men moving 3 coupled lengths of pipe per trip

2 One man moving 2 coupled lengths of pipe per trip

3 One man moving 1 length of pipe and coupler with riser per trip.

Moving methods varied with height of crop, experience and ability of the workmen, and size and length of lateral pipes. In irrigating corn, more labor was required for drilled planting than for checkrow planting. The most significant single factor in the time requirement was found to be the method of moving and the consequent difference in the number of trips. The method requiring the least number of trips generally shows the smallest labor requirement. Although these studies were not as extensive as the studies made by the Iowa State College (1), the results of the Nebraska field studies follow the same general pattern. Both studies point out the importance of the method used and emphasize the large amount of labor required in the operation of a sprinkler system.

A field study of 400 irrigation installations was conducted by the Nebraska Agricultural Experiment Station over the past three years in order to determine well and pumping costs. Power costs and unit water costs were found to be primarily influenced by the discharge head, and the total quantity of water pumped per season. The greater the annual usage of a pumping installation, the less influence fixed costs have upon total cost and the more important operating costs become. The curves on Fig. 1 illustrate this fact as well as the increased cost of pumping against pressure (14). For 780 hr. of annual pumping at 750 gpm under a head of 100 ft., the cost per acre-foot will be $8.15. If an additional head of 115 ft. (the equivalent of 50 psi needed for sprinklers) is added, the cost per acre-foot of water increases to $13.50.

This additional power cost of $5.35 per acre-foot is an important item in the comparison of the two systems.

The selection of the pump and power unit best fitted for the prevailing conditions, and the efficient operation of the equipment was found in this study to be very important. Results show that over-all plant efficiencies vary from 32 to 68 per cent. This variation was attributed primarily to mismatching the pump to the well, or to the motor, or both. Total power costs are directly proportional to the plant efficiencies.

The foregoing discussion indicates that the operating costs of a sprinkler system must be evaluated on the basis of maintenance, labor, and power costs. Maintenance will be largely determined by operating conditions and management. Labor costs will be governed by the number of irrigations, the layout of the system, the crop watered and the manner in which irrigation fits into the farm operation. Power costs will be dependent on discharge head, total hours of use, the selection of proper equipment and its efficiency. Table 3 shows the items to be considered in comparing the operating and maintenance costs of sprinkler and gravity irrigation systems.

TABLE 3 OPERATION AND MAINTENANCE COSTS

GRAVITY SYSTEM	SPRINKLER SYSTEM
Maintenance:	Maintenance:
Land preparation	Permanent ditches
Permanent ditches	Permanent structures
Permanent structures	Sprinkling equipment
Distribution equipment	
Operation:	Operation:
Cost of water	Cost of water
Laying and moving pipe	Cost for increased pressure
Construction of furrows, borders, and corrugations	Laying and moving pipe
Construction of annual ditches	
Filling of annual ditches	
Operating siphons, gated pipe, etc.	
Disposal of runoff water	

EFFICIENCY OF APPLICATION

The efficiency with which water can be applied may be the determining factor in the choice of a system, especially where water costs are high. Few data are available with which to determine the relative efficiency of sprinkler and gravity irrigation under plains conditions. However, a critical examination of the potential efficiency of each system can be made.

Water-application efficiency has been defined by the Committee on Irrigation of the American Society of Agricultural Engineers as follows: "The percentage of water applied that can be accounted for as soil moisture increase in the soil occupied by the principal rooting system of the crop" (4). This definition has been widely accepted and is in general use. However, it should be recognized that there are several characteristics of irrigation which are not reflected by this evaluation. Inadequate irrigation is not measured by efficiency as it is defined by the Committee. Poor distribution of water is likewise not reflected in the definition until a lack of uniformity results in deep percolation losses. By the Committee's definition, application efficiency is primarily a measure of overirrigation or wasteful irrigation.

The comparison of sprinkler and gravity irrigation will be based on the effectiveness with which water is used after it reaches the field, since methods of conveyance to the field are not necessarily associated with the type of distribution system. Conveyance losses would, of course, need to be estimated for each system on a particular farm. The ideal irrigation system is one which will provide the desired amount of water, distributed uniformly and applied at the highest rate possible without runoff and without damage to the soil or crop. A comparison will be made between sprinkler and gravity irrigation on the basis of their respective abilities to meet these requirements.

FEATURES APPROACHING IDEAL IRRIGATION

The sprinkler system offers some features which permit a close approach to ideal irrigation. Complete control over the amount of water applied can be achieved. Because of this feature, losses from runoff water can be eliminated, and deep percolation losses can be controlled. A sprinkler system can be designed to apply water at the proper rate. Problems arise at this point, however, since many forms have soils which vary in their intake rate. Frequently the system must be used on both bare soil and soil supporting a crop or covered with residue. Consequently, it may not be possible for a sprinkler system to meet accurately all the intake conditions found on a given farm.

The effects of the several factors on uniformity of distribution will be examined. These factors are pressure loss due to friction in the sprinkler lateral, the use of a circular pattern of distribution on a rectangular system, distortion of the distribution pattern by the wind, and spacing of laterals. The allowable pressure loss along the lateral line has been established in the proposed Minimum Standards for the Design of Sprinkler System published by ASAE. The allowable pressure loss of 20 per cent creates a reduction in discharge of about 10 per cent at the end of the line. It is safe to assume that in most systems the change in application rate from the main line to the end of the lateral will be near this allowable maximum.

Some lack of uniformity occurs due to the fact that a circular distribution pattern is applied to a rectangular system. Most studies of this problem have been made by operating one sprinkler, or one line of sprinklers and computing the uniformity coefficient by superimposing values thus obtained (3, 5, 6). Uniformity of distribution studies were made at the Nebraska Agricultural Experiment Station by operating two lines of sprinklers simultaneously. The spacing of the sprinklers was 40 x 40 ft. The sprinkler heads used were selected on the basis of similar discharge and speed of rotation. Hour long runs were made at constant pressure. The runs were made under the most favorable conditions possible, usually in the early morning. The depth of application was analyzed for that portion of the wetted area which was not affected by the overlapping of subsequent sets. The range of values (from low to high readings) for depth of application was found for each of ten runs. The range in depth averaged 15.4 per cent of the mean depth applied. This illustrates the fact that the best distribution which was found possible under field conditions falls considerably short of precise uniformity.

The effect of wind constitutes a serious distribution problem in sprinkler irrigation in the Great Plains states. Wind velocities through the growing season average near 10.0 mph at many weather stations. Christiansen (6) states that "wind exerts a major influence on distribution pattern". Molenaar (11) shows a sharp decline in uniformity of application due to winds of 3 to 7 mph. According to U.S. Weather Bureau records at Lincoln, Nebr., (13), winds of more than 7 mph occur 59 per cent of the total hours in the growing season. Winds of more than 3 mph occur 88 per cent of the time. Such wind velocities are typical of plains conditions and indicate the seriousness of this problem.

It is a common recommendation that sprinkler laterals should be placed perpendicular to the nominal prevailing wind direction so as to reduce distortion of the sprinkler pattern. The benefits from such a plan are dependent on the regularity of wind direction. A study of U.S. Weather Bureau records regarding wind direction reveals that the concept of prevailing winds on the plains is largely a mathematical one. Records of the per cent of time winds blow from the 8 principal directions at Lincoln, Nebr., will be used to illustrate this point (13). The records, over a period of 26 growing seasons, show that winds occurred from the nominal prevailing direction only 31 per cent of the time. If it is considered that the lateral direction is equally effective for winds 180 deg. from the prevailing wind, the total time that such a lateral would lie perpendicular to the wind would still be less than 50 per cent. Consequently, distortion to the distribution pattern will occur more than half of the time.

Other characteristics of the sprinkler system affect the distribution pattern under conditions of high wind velocity. Sprinklers placed closer together on the lateral, triangular spacing of sprinkler heads and the use of special nozzles have been shown to improve uniformity (6, 11). However, there is now a tendency toward the use of wider lateral spacing which usually reduces uniformity. Higher pressures which often accompany wider spacing produce a smaller drop size, which in turn increases susceptibility to wind disturbance.

EFFICIENCY OF SPRINKLERS AFFECTED BY TWO LOSSES

The efficiency of application of sprinklers is affected by two losses which do not occur with surface application. They are direct loss by evaporation from the spray and loss of water intercepted by vegetation and subsequently evaporated. The amount of these losses is much in dispute and is probably extremely variable. The direct loss is usually unimportant since the water is in the air for a relatively short period of time. Evaluation of interception loss from rainfall has been attempted by several workers. The results are very contradictory. Stoltenberg and Wilson (12) show a very low interception loss of 0.02 in for corn from a single storm. Other workers have shown losses up to ½ in or more. Since sprinkling is often practiced under temperature and humidity conditions conducive to rapid evaporation, it seems reasonable to expect that appreciable interception losses do occur.

The use of surface irrigation to achieve ideal water distribution is also beset by certain unavoidable difficulties. The first is the fact that it is not possible to apply water to all parts of the field for the same period of time, because time is required for the water to flow across the field. This difference in time is partly compensated for by the time required for the water to recede down the field after the supply is shut off. Under furrow irrigation the time of recession is usually a small per cent of the time required for water to cross the field. With border irrigation the recession may almost compensate for the time of advance and provide the desired uniform time of application. When differences in time of application are involved, complete irrigation of the lower end of the field will cause deep percolation loss at the upper end. Criddle (8) has estimated that this loss should not exceed 10 to 15 per cent when desirable irrigation practices are used.

FACTORS FORMING HAZARD TO EQUAL DISTRIBUTION

Small differences in slope and soils form an additional hazard to equal distribution. Slope variations occur even on land which has been reasonably well prepared for irrigation. Fitts, McHenry, and Allaway (8) in "Soil Studies for 1945" in Nebraska showed striking differences in depth of penetration of irrigation water on slopes which varied between the rather narrow limits of 0.3 to 1.2 per cent. Soil changes which are too small in area to be considered in placement of laterals will cause differences in amount of water intake. These facts indicate that the penetration pattern resulting from gravity irrigation may be quite irregular.

Runoff is another loss from gravity irrigation which can be controlled but cannot always be eliminated. A serious runoff problem is much less common in areas where individual farmers pump their water supply than in areas where water is supplied from ditches on an annual per acre cost basis. This fact indicates that the problem is economic as well as technical in nature. There are many farms on which it is either impractical or uneconomical to prevent runoff loss. The amount of such loss under good irrigation practice has been found to range from 0 to 15 per cent.

The determination of the probable efficiency of a proposed installation is the most difficult phase of evaluating the two types of irrigation. Both gravity and sprinkler systems, when properly designed and operated, are capable of high application efficiencies. Studies to evaluate these efficiencies have been made in Nebraska during the past three seasons. Fields on which good irrigation practices were used showed a range of application efficiencies from 62 to 87 per cent for both gravity and sprinkler irrigation. Lower application efficiencies are usually associated with the less desirable irrigation practices. Current studies will provide specific information on relative application efficiences under identical site conditions.

This discussion has dealt primarily with the irrigation of moderate slopes under typical Great Plains conditions, but the consideration of soil conservation objectives should not be overlooked. Irrigation may be the cause of erosion, or it may encourage practices which make the land more susceptible to erosion from rainfall. Some farmers in subhumid areas have changed their row direction from contour farming to downhill because of the introduction of irrigation. Sprinkler irrigation has some decided advantages in such areas. It can be used in connection with terraces or diversion structures where gravity irrigation is very difficult to practice. On the other hand, the land

preparation necessary for efficient gravity irrigation may be done in such a manner as to solve erosion problems. An example of a practice which solves both problems is the use of contour borders, or benches which provide for good irrigation as well as for controlling rainfall. The effect of the proposed irrigation systems on the soil conservation program for the farm should certainly be a factor in the final choice.

HUMAN FACTOR

The human element as a factor in comparing the two systems of irrigation is very real but difficult to evaluate. The operational requirements of the system and the irrigator's aptitude should be considered in making a choice. Although the system should be selected as objectively as possible, consideration must be given to the operator's personal preferences and experience. Irrigation is not only a science, but also an art. For this reason, the selection of a system suited to the operator's ability and desires will increase the probability of successful irrigation.

SUMMARY

1 Initial cost of sprinkler and gravity irrigation systems can be estimated for a particular farm on the basis of the items in Table 1. No general statement of comparative first cost for adequately designed systems can be substantiated.

2 Depreciation can be calculated on the basis of the periods suggested in Table 2. Land grading is not depreciated, but other features of both systems require replacement.

3 Operating costs are made up of maintenance, labor and power costs. For gravity irrigation proper charges must be made for preserving the surface conformation secured by land preparation. Power costs for producing pressure necessary for operation of sprinklers are shown to be a significant factor in comparative operating costs. Table 3 lists the items to be considered in evaluating operating costs.

4 The effective use of water is dependent not only upon application efficiency, but also upon uniformity of distribution. Uniformity by sprinkler irrigation is adversely affected by pressure loss in laterals, circular distribution pattern, and wind. With gravity irrigation, the factors detrimental to uniformity are differences in time of application at the top and bottom of the field, and slope and soil irregularities.

5 The selection of an irrigation system should be made only after taking into consideration personal factors including preferences, aptitudes, and background of the irrigator.

CONCLUSIONS

Sprinkler and gravity systems of irrigation are rivals in the sense that one or the other must be chosen to serve a given farm or field. They are not rivals in the sense that one method is likely to completely replace the other under Great Plains conditions. This paper has pointed a method for making a rational choice between the two systems when the conditions under which they must operate are known. The adequate design of a farm irrigation system will include the consideration of all possible methods of application. The decision should be based on the ability of one system to best meet the existing conditions.

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Drainage as a Production Tool

(Continued from page 242)

drainage over extensive areas already provided with outlets. Crop production can be doubled on some 20 to 30 million acres by following such a program, without requiring the use of any additional farm machinery, seed, fertilizer, or farm labor. It is an economical method of increasing crop production.

The drainage of undeveloped swamp or wet areas suitable for agricultural production is in many instances desirable, but should be undertaken only after thorough consideration has been given to the relative value of the areas to the nation as recreational areas, wildlife habitats, or forest lands.

Prestressed Concrete

(Continued from page 245)

together allowed the mild steel to lose most of its 25,000 to 30,000 psi initial prestress.

Today high-carbon steels having ultimate strengths of 200,000 psi or more are available from several American manufacturers. Most of these steels can safely be stressed to 150,000 psi with no permanent set. The loss due to creep and shrinkage probably never exceeds 25,000 psi, which still allows 125,000 psi stress to remain permanently in the steel.

High-strength concrete is also essential to attain the ultimate advantages of prestressed concrete. Higher allowable compressive strengths permit reduced cross-sectional areas with the corresponding reduction in dead weight. Creep and shrinkage factors are also less in high-strength concrete. Concrete having at least an ultimate strength of 5,000 psi at 28 days is recommended.

Through-Circulation Drying of Cut Corn

R. L. Ditsworth and E. W. Jerger

INVESTIGATORS heretofore have proposed a number of theories on the mechanisms of moisture flow in different materials, and have set up equations defining these mechanisms. However, there is considerable controversy in their assumptions and lack of correlation in their data. Reliable information on drying from acceptable theoretical principles and/or empirical relationships is particularly necessary in the design of driers and in the control of drying operations to insure a desirable end product with maximum economy.

OBJECT OF INVESTIGATION

The purpose of the study reported in this paper was to investigate the drying schedule of cut sweet corn using through circulation of conditioned air. The mechanisms of moisture movement in organic solids such as sweet corn are difficult to express mathematically. Therefore, data concerning the drying characteristics of cut sweet corn must be obtained experimentally.

DESCRIPTION OF APPARATUS

Air Conditioner. The air-conditioning system consists of three air intakes with air proportioning dampers, a steam humidifier, filters, steam coils, chilled-water coil, cooling coil, air washer, eliminator plates, fan, and electrical heating units. A schematic diagram of the air conditioning system is shown in Fig. 1.

Drying Cabinet. The drying cabinet, approximately 9 ft high and 4 ft square, includes inlets and outlets that allow the air to be blown either through or over material to be dried. Four one-foot-square product pans were used. An isometric view of the drying cabinet is shown in Fig. 2.

Instrumentation. The dry-bulb temperature of the air entering the drying cabinet was taken about one foot above the trays with a Bristol Recorder Model 340m. Air temperature leaving the drying unit was determined with the Bristol Recorder Model 240m. Recorders were calibrated against mercury-in-glass thermometers shielded with aluminum foil. The thermometers were certified by the National Bureau of Standards.

Wet-bulb and dry-bulb temperatures of the supply air were determined by using a Taylor Tycos recording unit. This motor-driven unit was located in the spray chamber because of this instrument's limited temperature range. Wet-bulb and dry-bulb temperatures were taken to determine the dew point of the air supplied.

Internal and surface temperatures of the corn were taken with a Brown strip-chart potentiometer, using copper-constantan thermocouples. Eight temperature readings were taken at repeated intervals with this multipoint recorder.

A velocity traverse of the air at the exit of the drying unit was taken with an Alnor velometer that was calibrated by the Illinois Testing Laboratories.

TESTS AND PROCEDURE

Frozen cut sweet corn was used in this investigation. Specific information concerning the variety and date of harvest was not available. The unblanched corn was frozen in bulk form. It was stored at a temperature of 0 F until it was taken for drying.

The amount of corn used in each run was approximately 2200 g. The moisture content of the corn was initially determined for each sample by drying to a constant weight in a vacuum oven at 0—50 mm Hg pressure. The sample to be dried was placed in four trays in a one-kernel thickness covering the one square foot of pan area. These trays were placed in the drier on the horizontal supports. Eight thermocouples were inserted in kernels located at random in two trays, four to obtain the internal, and four to obtain the surface (the thermocouple was pushed through the cut section of the kernel until it contacted the pericarp on the opposite side) temperatures of the kernels. These trays were not disturbed during the drying run. The other two trays were removed and weighed on a triple-beam balance at half-hour intervals for the first two hours, then at one-hour inter-

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

The authors — R. L. Ditsworth and E. W. Jerger — are, respectively, instructor in theoretical and applied mechanics and assistant professor of mechanical engineering, Iowa State College.

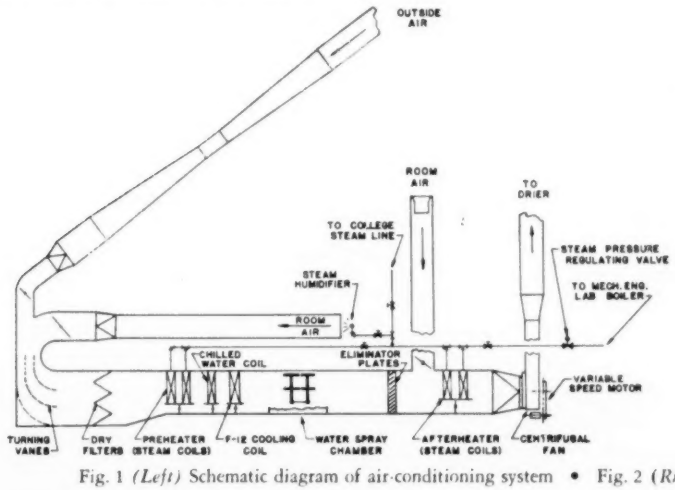
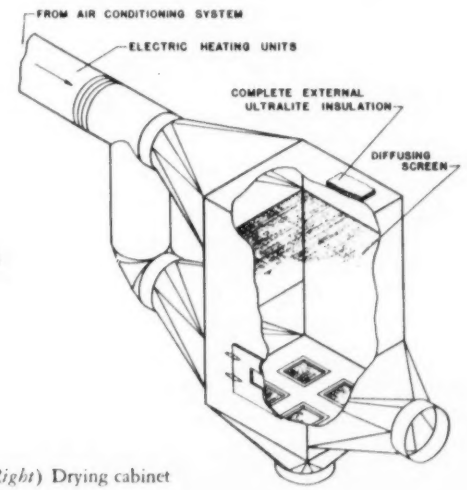


Fig. 1 *(Left)* Schematic diagram of air-conditioning system • Fig. 2 *(Right)* Drying cabinet



vals for the remainder of the test period. The number of drying runs made and the nominal conditions are shown in Fig. 3.

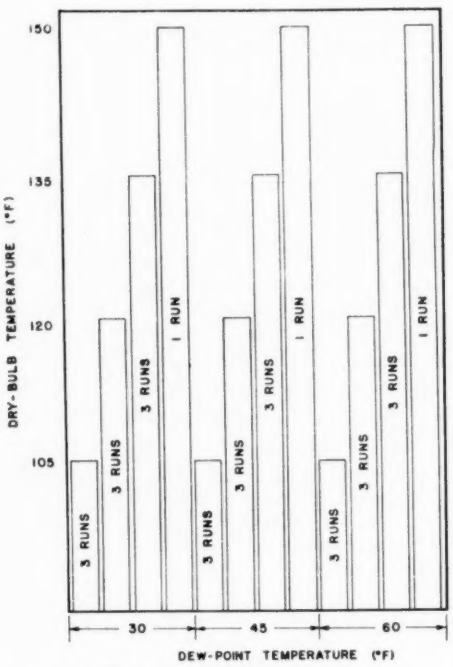


Fig. 3 Schedule of drying runs

TEST RESULTS

Upon analyzing the data for all of the runs, there was no significant difference in the data of each replicate; hence one run for each drying condition was selected as representative. These runs were analyzed for drying characteristics of cut sweet corn. The drying schedule of a typical set of runs is given in Fig. 4, with moisture concentration C plotted against time. The moisture concentrations were calculated on a dry basis. Drying rate curves were prepared using the tangent-slope method. Fig. 5 illustrates graphically the drying rate of run No. 7. The variation of corn temperature with time is given in Fig. 6. This corn temperature is an arithmetic average of the eight temperature readings, as there was only a fraction of one degree difference in the internal and surface temperatures of the kernels. In most cases after two hours of drying, the corn-surface temperature was not significantly different from the dry-bulb temperature of the air. For the drying runs at the nominal temperature of 150F, the corn temperature was estimated as indicated in Fig. 6.

The theory is proposed that heat is transferred from the air to the corn, and that the liquid water in the kernel vaporizes. Independent studies indicate that as the kernel dries, the liquid reservoir in the kernel recedes towards the center leaving an outside shell of dry solid. Theorizing further that the vaporized water diffuses through this dry solid to the outside, the drying mechanism may be described in terms of the mass transfer of water vapor from the surface into the air stream as indicated in the following equation:

$$dC/d\theta = K\ (P_s - P_w) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [1]$$

where $dC/d\theta$ = rate of drying
K = mass transfer coefficient
P_s = pressure of water vapor at the corn surface temperature
P_w = partial pressure of water vapor in the air stream.

It is observed that the drying potential governing the rate is assumed to be the pressure difference of vapor at the corn surface temperature and the partial pressure of the water vapor in the drying air.

Values for K were calculated from the data using equation [1]. These values of the mass transfer coefficient were then plotted on log-log coordinates against moisture concentration (Fig. 7), and a linear relationship observed. The following equation was calculated to represent these data using a method of least squares:

$$K = -0.418 C^{1.591} \quad [2]$$

where K = mass transfer coefficient in grams of water per gram of dry solid per hour per inch of mercury pressure difference.

C = grams of water per gram of dry solid.

By replacing K in equation [1] with the expression found in equation [2], the following relation resulted:

$$dC/d\theta = -0.418\ C^{1.591}\ (P_s - P_w) \quad . \quad . \quad . \quad . \quad [3]$$

CORRELATION AND INTERPRETATION OF TEST RESULTS

The drying-schedule curves represent the drying times of cut sweet corn when samples were subjected to different conditions of air temperature and humidity. Examination of the drying rate curves shows that the rate of drying is affected by the air dry-bulb and dew-point temperatures. Drying takes place at a faster rate at higher air temperatures. Drying is slower as the dew-point temperature is increased for a given dry-bulb temperature. *(Continued on page 254)*

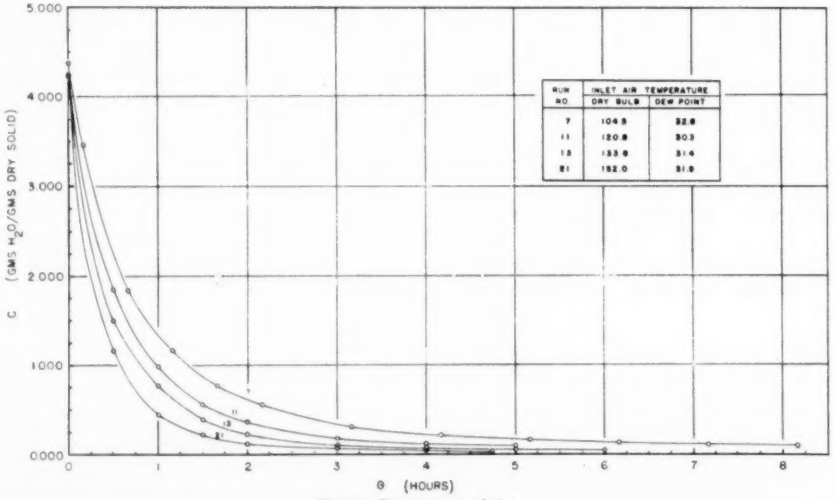


Fig. 4 Drying schedules

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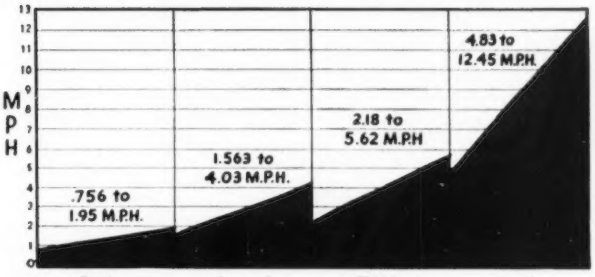

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Drying of Cut Corn

(Continued from page 252)

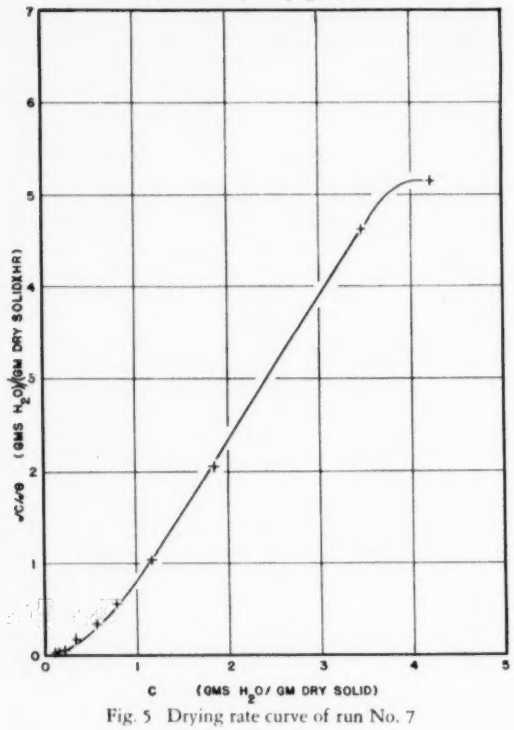

Fig. 5 Drying rate curve of run No. 7

In all of the runs, moisture was removed very rapidly during the first few hours of drying. In Fig. 4 the moisture content drops rapidly for the first two hours, and then approaches the equilibrium moisture content of the corn asymptotically. The curve showing the drying rate of run No. 7, Fig. 5, indicates that the dehydration of the corn occurs substantially as a falling-rate period. Data is not available to ascertain the true nature of the initial part of the curve. This interim was a warmup period and could have included a brief constant-rate period. The falling-rate period is divided into two distinct zones. The transition from the constant falling-rate period to the variable falling-rate period occurred when the moisture content (C) was approximately 1.0 g of water per gram of dry solid.

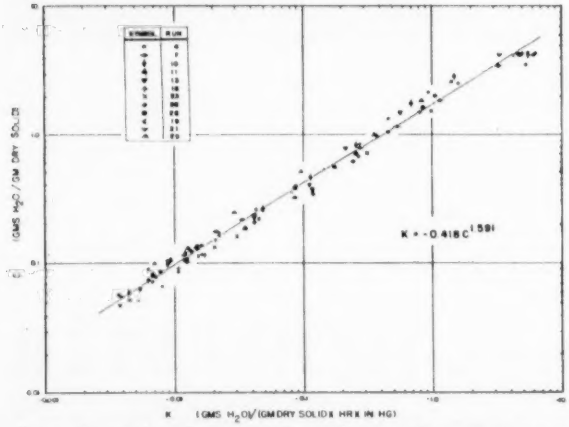

Fig. 7 Correlation of mass transfer coefficient with moisture content

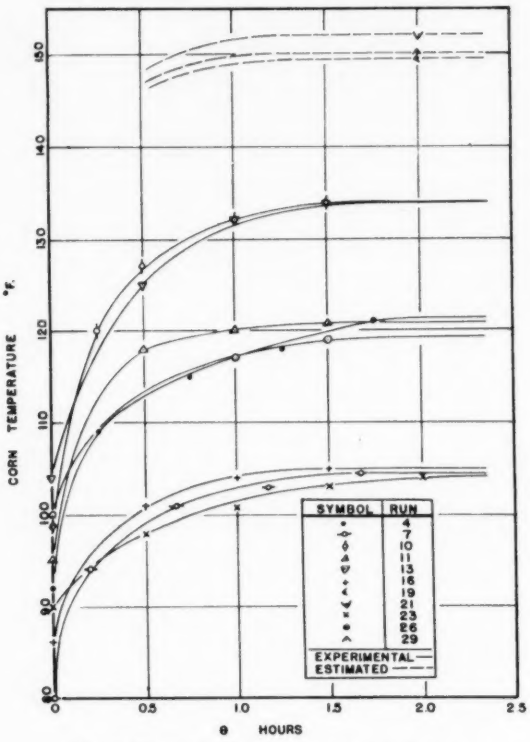

Fig. 6 Variation of corn temperature with time

The influence of air velocity on drying rates has not been included as one of the pertinent variables. It had been determined previously* that a variation of air velocities from 23.3 to 51.0 fpm did not have an appreciable effect on corn drying rates.

The relation of the drying rate of cut sweet corn to a mass transfer coefficient and the difference of water vapor pressures (equation [3]) is an expression found to be valid for the range of conditions investigated. The relationship was derived from data observed throughout the entire period of drying. Although the initial warmup period is an unsteady drying period, the values for K in that range are reasonable in relation to the other values of K for the falling-rate period.

CONCLUSIONS

The following conclusions may be drawn concerning the characteristics of through-circulation drying of cut sweet corn within the range of conditions studied:

1 The internal and surface temperatures of the kernels of corn assume the temperature of the air after two hours of drying.

2 Virtually all of the drying takes place in a falling-rate period. This period is divided into two distinct zones. The relationship of drying rate and moisture content is linear in the first zone and curvilinear in the second zone.

3 The rate of drying is proportional to the moisture content and vapor pressure difference as folows:

$$dC/d\theta = -0.418\, C^{1.591}\, (P_s - P_w)$$

4 A uniformly dried product is obtained.

*Jerger, E. W., Mechanism of moisture movement in the drying of organic granular solids, unpublished Ph.D. thesis, Iowa State College Library, 1951, p. 71.

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INSTRUMENT NEWS

KARL NORRIS, Editor

Sponsored by the ASAE Committee on Instrumentation and Controls. Contributions on agricultural applications of instruments and controls and related problems are invited, and should be submitted direct to K. H. Norris, Agricultural Research Center, Beltsville, Md.

Thermistor Temperature Bridge

J. G. Taylor and M. T. Orem

MEMBER ASAE ASSOC. MEMBER ASAE

A DIRECT-READING thermistor bridge for blood-temperature measurements was described by Drummet and Fastic of Johns Hopkins University in 1947 (1)*. The advantages of fast response, high accuracy and simplicity of construction, claimed for this instrument, seemed desirable to replace fever thermometers in our work involving measuring the body temperatures of newborn pigs, so a similar instrument was built incorporating an improved switching circuit. The instrument, shown in Fig. 1, permits temperature readings in the range of 68 to 112 F with an accuracy of 0.2 F. The time required for each reading is about 30 sec compared with the 2 to 4 min required with a fever thermometer. Similar instruments could be designed for other temperature ranges and applications.

The authors—J. G. TAYLOR and M. T. OREM—are agricultural engineers (BPISAE), U.S. Department of Agriculture, cooperative with Purdue University.

*Numbers in parentheses refer to the appended references.

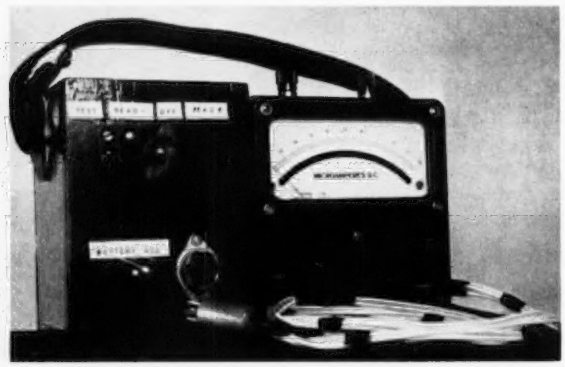

Fig. 1 Thermistor temperature bridge used for body temperature measurements of pigs

The circuit of the instrument is shown in Fig. 2. It is essentially a direct-reading Wheatstone-bridge circuit, one arm of the bridge consisting of a thermally sensitive resistor, or thermistor (2). The bridge is powered by two $1\frac{1}{2}$-v flashlight batteries which are mounted within the case. The meter used to measure the bridge deflection is a high-resistance 0-100 microammeter with an accuracy of 0.5 per cent. A single, four-position, four-pole selector switch functions as an on-off, reversing, and battery-test switch.

The reversing feature allows double use of the meter scale as temperature readings may be made each side of the bridge balance point. If desired a zero centering meter may be used eliminating the need of this feature.

In "test" position the thermistor is disconnected from the circuit and the battery adjust potentiometer may be set to bring the meter to a predetermined setting assuring correct voltage impressed across the bridge. The battery life is long and adjustment is seldom needed although it should be checked before the initial readings are taken of each new group of temperature measurements.

A momentary contact, normally closed, miniature switch is connected across a series-protective resistor to prevent overloading the meter. This switch is conveniently mounted on the meter probe and is depressed when a reading is taken.

The bridge circuit was mounted in a 3 by 5 in card-file box and the file box and meter were then attached to a small plywood base. The balancing potentiometer was mounted inside the case so that it could not be adjusted inadvertently. Precision resistors with a low-temperature coefficient of resistance were used as fixed resistors in the bridge arms. The thermistor is a Western Electric type 14B. In order to prevent breakage it is slipped into a glass tube drawn to a diameter slightly larger than the thermistor shank.

The thermistor bridge is calibrated by first adjusting the battery voltage and then checking the bridge deflection against a highly accurate ther- *(Continued on page 258)*

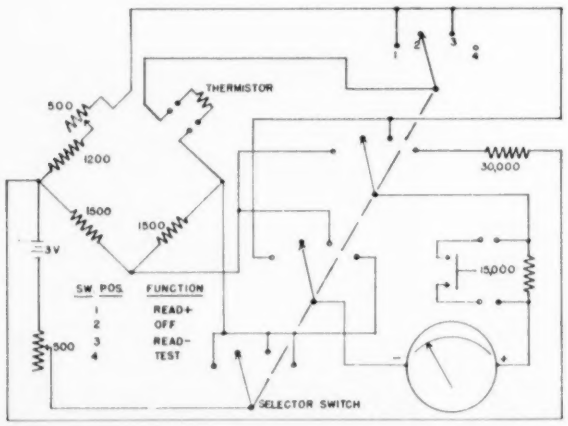

Fig. 2 Circuit diagram of termistor temperature bridge. Meter is a Weston model 931, 0-100 microamp, 1277 ohm; selector switch is a Mallory type 177C.; thermistor, Western Electric, type 14B

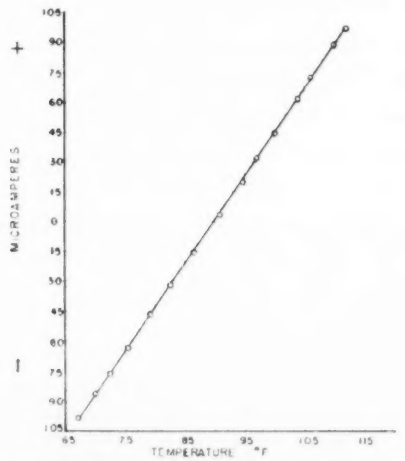

Fig. 3 Typical calibration curve for thermistor temperature bridge

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HYATT ROLLER BEARINGS

Thermistor Temperature Bridge

(Continued from page 256)

mometer with both thermometer and thermistor placed in an oil or water bath. The precision of the thermistor bridge can be no higher than the instrument and that of the method by which it is calibrated. It was found that, over the 44 F temperature span used, the bridge deflection was essentially linear, the only non-linearity occuring at the extreme ends of the temperature span. The balancing potentiometer in the bridge circuit permits slight shifting of the temperature range to obtain the range desired. A typical calibration curve is shown in Fig. 3.

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Simple Measurements of Small Time Interval

F. C. Jacob
ASSOC. MEMBER ASAE

ELAPSED times of hundredths of a second between two events can be readily and accurately measured with common electrical-measuring equipment. Continuous mechanical motion can be timed with a stroboscope, tachometer, etc.; but timing intermittent or non-recurring movements of a hydraulic ram, trip device, or electrical solenoid linkage requires different instrumentation. When microswitches or other electrical contacts can be made to operate at the beginning and end of the motion to be measured, the following method will work.

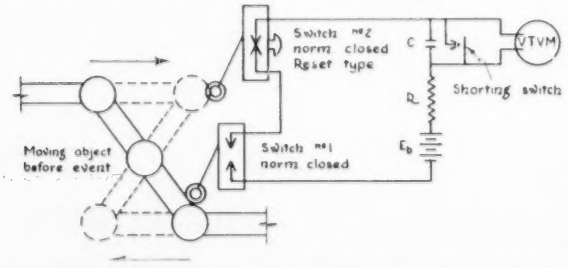
The equipment required is a very high-resistance d-c voltmeter, such as a vacuum-tube voltmeter, resistor and condenser of known values, microswitches, and battery. The resistor and condenser wired in series will have a "time constant" such that to charge the condenser through the resistor to a voltage E_c, from a battery of E_b volts requires time in seconds, T, of

$$T = R\,C\,ln\,E_b/(E_b - E_c)$$

where R is the resistor value in ohms and C is the condenser value in farads.

One microswitch should be of the normally closed type. The other should be the normally closed reset type so that when operated it remains open until reset. The first switch is located so that before the event begins, the object to move presses against the switch lever holding the contacts open.

The author—F. C. JACOB—is assistant specialist in agricultural engineering, University of California.



Circuit diagram for equipment used in measuring small time intervals

As the event starts, the moving object releases the switch lever allowing the switch to assume its normally closed condition. The second switch with reset feature is located in such a way that, at the termination of the event, the moving object strikes the switch lever throwing the switch contacts from closed to open. Even if the moving object continues in motion, the reset feature of the switch prevents any further operation of the timing circuit. The switch must be reset before another measurement is made.

The accompanying diagram shows the circuit before the event begins. The switches, battery, resistor, and condenser are all wired in series. The switches close the circuit only during the event to be timed. The voltmeter is connected to read the resulting voltage E_c across the condenser. The condenser must be discharged by shorting it before each measurement. If the condenser has paper dielectric and is wax or oil-impregnated, not electrolytic, so as to have low leakage, and if the voltmeter resistance in ohms multiplied by the condenser capacity in farads is, say 50 sec or longer (the discharge time-constant of the circuit), then the condenser will not lose appreciable charge before a reading can be made. The product $R \times C$ (the charging time-constant) should preferably be several times larger than the time interval to be measured. The microswitches may mechanically bounce or chatter for about 2 milliseconds when operated, and so measurement of intervals shorter than 10 or 20 milliseconds should not be attempted unless better switching is available.

For measuring intervals of about 10 to 100 milliseconds, values of $R = 300{,}000$ ohms, $C = 1 \times 10^{-6}$ farad, and voltmeter resistance of 100 meg-ohms give measurement accuracy of about 5 per cent, depending on how closely values of R, C, and E_b are known, and on how quickly the meter is read after the event. The battery voltage E_b should be about equal to, or higher than, the voltmeter scale used.

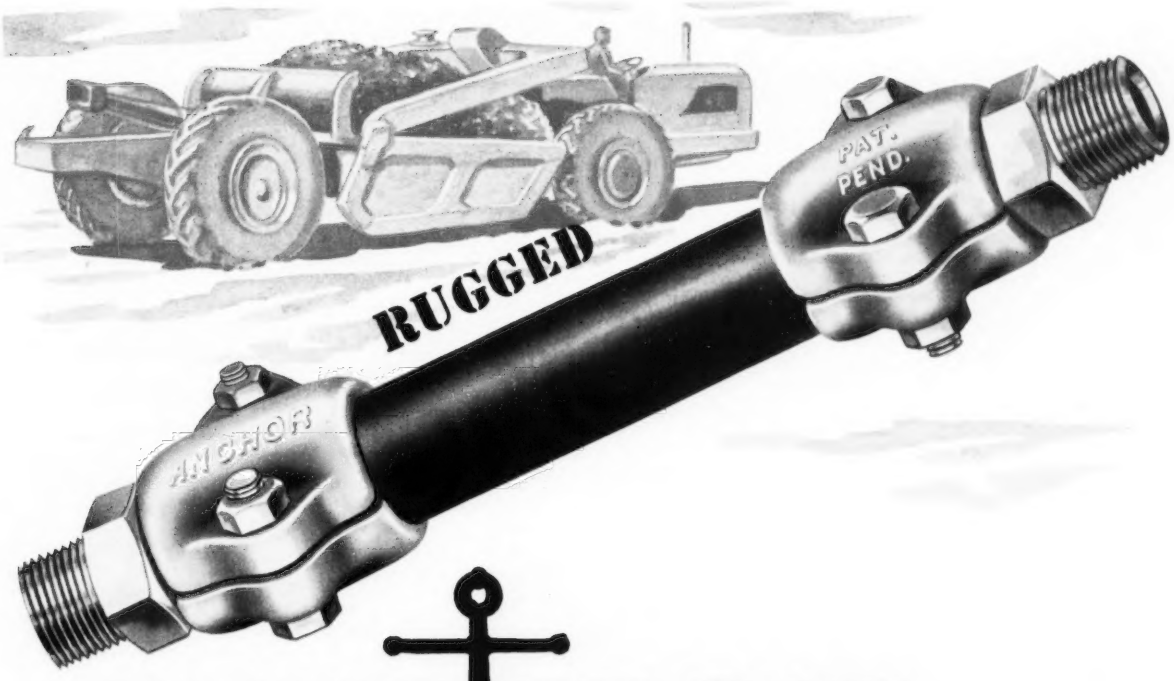
Arrangements using an oscillator and an oscilloscope or an electronic counter can be used to advantage for measuring even shorter time intervals.

Potato Storage

(Continued from page 230)

Changing from dry to washed grading has changed the grader from a light portable machine to a heavy stationary one. When the dry grader was moved into the bins the graded and sacked potatoes moved direct from bin to car. In prewasher days storages were designed so potatoes could be moved outward and downward into bins, through roof hatches, through floors or from upper drives. This saved labor and fitted in well with underground and two-floor storage design, but no way has been developed for putting potatoes down into bins without excessive injury. Now the problem not only is to devise better ways of putting potatoes into present deep bins and basement bins, but also to devise ways for moving them from these bins to stationary washers and graders without adding new injuries, which are easily seen in the washed potatoes. Best method so far devised for moving potatoes from bin to stationary grader is by flume, in one-level storage and washing plants, and by flume and elevating conveyors in two-level storage and washing plants.

At the present time handling factors outweigh other considerations so the best design for new seed and table stock storages is the grade-level one-floor design with a minimum of partitions.



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NEWS SECTION

ASAE Officers for 1953-54

AS THE result of the regular election of officers of the American Society of Agricultural Engineers conducted by letter ballot of the corporate members of the Society during February and March, the following officers have been elected and will take office at the close of the Society's annual meeting to be held in Pittsburgh, Pa., June 14 to 17:

President—Edwin W. Tanquary, engineering specialist, farm implement division, International Harvester Co., Chicago.

Vice-President (3-year term)—James W. Martin, head, agricultural engineering department, University of Idaho, Moscow.

Councilor (3-year term)—Harry Dearing, Jr., agricultural engineering, Tennessee Coal and Iron Division, United States Steel Corp., Birmingham, Ala.

Nominating Committee—E. G. McKibben (chairman), director, agricultural engineering research, U.S. Department of Agriculture, Beltsville, Md.; R. H. Driftmier, head, agricultural engineering department, University of Georgia, Athens, and R. R. Poynor, general supervisor, farm practice research, International Harvester Co., Chicago.

The members of the Council for the Society year 1953-54 will include the above newly elected officers together with the following: Stanley Madill and Ivan D. Wood, past-presidents; E. L. Hansen and L. H. Skromme, vice-presidents, and Howard Matson and H. N. Stapleton, councilors.

Members of the Society are invited to send any member of the Nominating Committee such suggestions as they may have for nominees for election of officers of the Society in the next annual election of officers which will be held in February and March, 1954. It is desirable that such suggestions reach the nominating committee on or before June 1, 1953.

Watson Heads Pacific Coast Section

FRANKLIN H. WATSON, JR., agricultural engineer, East Bay Municipal Utility District, Lodi, Calif., was elected new chairman of the Pacific Coast Section of the American Society of Agricultural Engineers at its annual meeting, February 27 and 28, on the campus of the California State Polytechnic College at San Luis Obispo. He succeeds J. R. Tavernetti, University of California. Elected also at the meeting was B. L. Hagglund, sales manager, Caterpillar Tractor Co., as the new vice-chairman of the Section. The perennial secretary-treasurer of the Section was elected for another year—Walter W. Weir, drainage engineer, department of Soils, University of California, Berkeley. Kenneth R. Frost, assistant professor of agricultural engineering, University of Arizona, was elected a member of the Sections' executive committee

More than 50 members and guests of the Section attended the meeting.

The meeting opened with a welcome to the CSPC campus by the president of the College, Julian A. McPhee, which was followed by a talk on the agricultural engineering curriculum at the institution by J. F. Merson of the agricultural engineering staff. The remainder of the opening session included papers on operation and economics of chopped green feeding by Wallace Sullivan of the California Agricultural Extension Service, on the mechanical clearing of brush by Joseph Muir, also of the Extension Service, and calculating land leveling for irrigation by J. C. Marr, University of California.

The second session opened with the annual business meeting of the Section, and was followed by a technical program including a paper on deep well pump wear studies by C. A. Lamb, a mechanical engineer, and a second paper on the hydraulic characteristics of pipe

(News continued on page 262)

ASAE Meetings Calendar

April 23 and 24—PENNSYLVANIA SECTION, Agricultural Engineering Bldg., Pennsylvania State College, State College

April 28—IOWA-ILLINOIS SECTION, Ship's Wheel, Campbell's Island, East Moline, Ill.

May 1 and 2—ALABAMA SECTION, Alabama Polytechnic Institute, Auburn

May 1 and 2—VIRGINIA SECTION, Natural Bridge Hotel, Natural Bridge, Va.

May 8—MINNESOTA SECTION, Agricultural Engineering Bldg., University Farm, St. Paul

June 15 to 17—46TH ANNUAL MEETING, Hotel William Penn., Pittsburgh, Pa.

August 31 to September 2—NORTH ATLANTIC SECTION, Long Island Agricultural and Technical Institute, Farmingdale, L. I., N. Y.

December 7-9—WINTER MEETING, Edgewater Beach Hotel, Chicago, Ill.

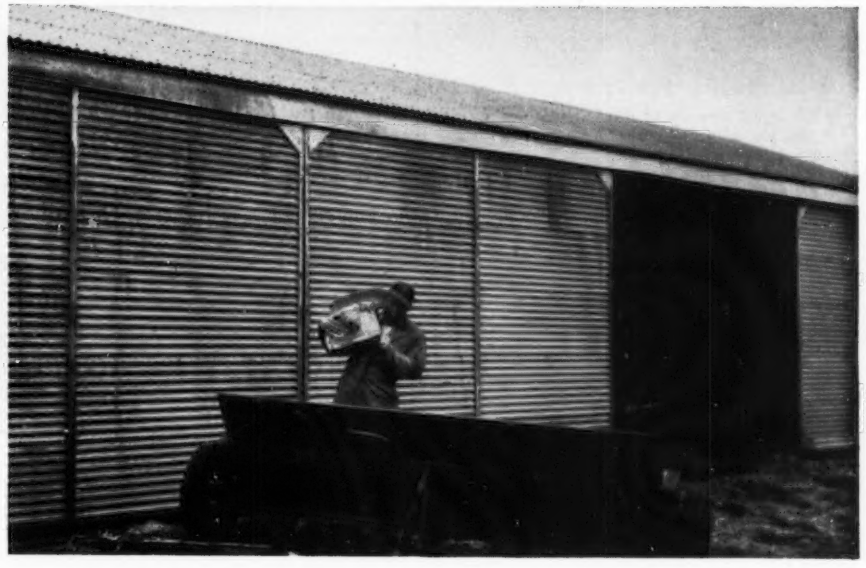
NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to ASAE, St. Joseph, Michigan

This is Pittsburgh where the ASAE 46th Annual Meeting will be held June 14 to 17, 1953. The Allegheny River from the upper left joins the Monongahela River from the right to form the Ohio. In this setting is the "Golden Triangle" of Pittsburgh. Headquarters for the ASAE meeting will be in the Hotel William Penn, which is located in the shadow of the square-topped United States Steel Corporation building. The highway in the right foreground is routes US 22 and US 30 from the west. The meeting program will include an opportunity to see the industries of the Pittsburgh area.

IN ADDITION to this steel building being used for farm machinery storage, a section of it frequently doubles as a garage.

"This steel building sure saves my machinery"

SAYS RICHARD FORREST, MANSFIELD, ILLINOIS



THESE LARGE SLIDING DOORS permit heavy machinery to be driven in and out of the building without difficulty.

MR. FORREST farms 320 acres as a tenant on the farm of A. F. Cousey. What has impressed him most about his steel building is its rugged durability. "This is a fine building," he says. "I expect it to last a long time."

Mr. Forrest uses his steel building mostly for machinery storage. He appreciates the excellent protection that those wind and rain-proof steel sheets can give. "This steel building sure saves my machinery," he says, "and I never have to worry about it catching fire."

Steel is the ideal material for farm buildings, because steel buildings give exceptionally long service with extremely low maintenance cost. And their wide-open interiors let you drive right in. No danger of running into a supporting post. There aren't any.

With the warm weather coming on, the time is ripe to put up a steel building. You'll want to be prepared for next winter and all the winters to come. So act now! And remember, *you get more for your money when you build with steel.*

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County ..... **State** .....

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NEWS SECTION (Continued from page 260)

systems for irrigation by A. F. Pillsbury and E. H. Taylor of the University of California, Los Angeles. The remainder of the session was devoted to a symposium on sprinkler irrigation, with R. J. Hilbe, Hilbe Engineering, Inc., speaking on the engineer in sprinkler irrigation and A. S. Gray, National Rain Bird Sales and Engineering Corp., on conservation of soil and water as related to sprinkler irrigation. A. H. Hendrickson, pomologist and F. J. Veihmeyer, irrigation engineer, University of California, discussed the subject of sprinkler water application in orchards.

The section dinner was held on the evening of the first day with Thor W. Christensen, a past-chairman of the Section, acting as master of ceremonies. The feature of the program was an illustrated talk by Martin R. Buberty, chairman, department of irrigation and soils, University of California, Los Angeles, on agricultural problems of the Near and Middle East.

The second day's technical program included papers on a harvester for sugar beets in Ireland by A. A. Armer, Spreckles Sugar Co.; the problems in industrial design for agricultural products, by R. E. Stillwell, project engineer, John Bean Div., Food Machinery and Chemical Corp.; engineering design of a livestock enterprise by C. F. Kelly and T. E. Bond, respectively, University of California and U.S. Department of Agriculture, and research in air currents from agricultural aircraft by W. E. Yates, University of California.

Electrofusion Features ASAE Section Meeting

A DINNER meeting of the Iowa-Illinois Section of the American Society of Agricultural Engineers held in East Moline, Ill., March 6, broke all records of attendance of the meetings of the Section since it was organized — 154 ASAE members and guests.

The program following the dinner opened with a talk by John T. Brown, executive vice-president in charge of manufacturing of the J. I. Case Co., on the subject "Production Practices as Related to the Design Engineer." Mr. Brown referred to designing as a creative process and discussed the relationship of the manufacturing processes and developments and how the designer can best use the existing facilities in creating a new product with a minimum of capital outlay for new tools and time, all pointed toward a better, lower-cost product in quicker time. His talk was enthusiastically received.

W. J. Farrell, chief application engineer for Sciaky Bros., Chicago, and a specialist in the field of electrofusion, explained that electrofusion is the method of joining plates, bars, rods and various other shapes together by the use of electric current and with no extra metal electrodes such as is used in arc welding. He illustrated with slides the uses of electrofusion in common applications and the advantages gained such as cost saving, simpler design, and increased strength. He enumerated some of the points through which quality control can be accomplished, namely, control of materials, control of dimensions of parts, control of cleanliness (no scale on parts), and setting up a chart with provision for following it on the machine's control panel.

The next meeting of the Section will be on Tuesday, April 28, one of the attractions of which will be a tour of the International Harvester Company's plant at East Moline, Ill. The program and dinner for the meeting will be at the Ship's Wheel on Campbell's Island at East Moline.

Southwest Section Meeting

THE regular yearly meeting of the Southwest Section of the American Society of Agricultural Engineers is being held April 10 and 11 on the campus of the Oklahoma A. & M. College, Stillwater. During the forenoon of April 10 there will be three concurrent programs. One of these will include a discussion of the progress in the performance of stalk shredders and brush cutters by J. S. Tanner of the Servis Equip. Co. James R. Coover of the Soil Conservation Service will talk on soil characteristics and conditions influencing irrigation system design. Instruments of soil conservation will be the subject of a talk by W. T. Wheeler of the International Harvester Co., and Grant Woodward of the Soil Conservation Service will discuss problems encountered in converting farm equipment from dry land to irrigation use.

The second program will open with a talk on pond water treatment for farmstead use by E. R. Daniel, Oklahoma A. & M. College, and will be followed by J. P. Hollingsworth, USDA, discussing light traps in checking the spread of the pink bollworm. New developments in farm structures is the subject of a talk by Roy E. Hayman, Public Service Co. of Oklahoma, and F. T. Watten, USDA, is scheduled to speak on dielectric treatment of rough rice.

The third program of this period is being arranged for students attending the meeting, and it will be addressed by Charles E. Ball, one of the field editors of *Farm Journal*. In addition there will be reports from student branches in the area of the Southwest Section, namely, from the University of Arkansas, Louisiana State University, Oklahoma A. & M. College, and A. & M. College of Texas.

The afternoon of the first day will be devoted to concurrent programs, one of which will open with a talk comparing gasoline and LP gas as a fuel for medium or small farm tractors by T. F. Maher of Southwestern Louisiana Institute. This will be followed by a field trip to the Stillwater Outdoor Hydraulic Laboratory where a demonstration of the performance of full-size soil conservation structures will be made by W. O. Ree of the Soil Conservation Service.

The second program for this period will include a talk on handling feed with less labor by M. M. Mayeux and Robert P. Kay, Louisiana State University. Ross Mauney, Arkansas Power and Light Co., will report on field tests with underheat electric brooders. Portable grade A dairy barns will be discussed by G. W. A. Mahoney and G. L. Nelson of Oklahoma A. & M. College. R. N. Craig, A. & M. College of Texas, will demonstrate electrical safety in the home and shop.

The Section dinner will be held in the evening with E. C. Buie, chairman of the Southwest Section, presiding.

The program on April 11 will open with a discussion of flood irrigation in the Southwest by C. W. Bracher, Able Construction Co., and he will be followed by L. F. Curl, U.S. Bureau of Entomology and Plant Quarantine, who will speak on the economic importance, the spread, and procedures for controlling the pink bollworm in cotton. This will be followed by J. E. Ferguson, Southern Irrigation Co., speaking on the subject of sprinkler irrigation in the Southwest. Frank B. Lanham, assistant secretary of ASAE, will present a report on ASAE headquarters activities.

The program will be concluded with the Section business session which will include election of officers for the ensuing year.

Mid-Central Section Meeting

THE Mid-Central Section of the American Society of Agricultural Engineers held its yearly meeting at the Robidoux Hotel, St. Joseph, Mo., on March 27 and 28. The meeting opened with a limbering up session, in the form of bowling, which occupied the group attending the meeting during the afternoon of March 27. This was followed by the Section dinner in the evening.

The evening was devoted to a panel discussion on training agricultural engineers with F. C. Fenton, Kansas State College, as moderator. O. H. Day, Butler Mfg. Co., and J. M. Tucker, Thomas Hydraulic Speed Controls, Inc., discussed the subject of what industry expects of agricultural engineers, while M. M. Jones, University of Missouri, and L. W. Hurlbut, University of Nebraska, presented views on how the colleges can best meet requirements for proper training of agricultural engineers for industry and other forms of employment.

The program on the forenoon of March 28 was devoted to a symposium on the production, handling and storage of forage crop. The speakers included P. L. Kelly of the University of Nebraska discussing cost of forage production, and M. L. Esmay of the University of Missouri talking on the handling and storage of grass silage. The development of a new type of simplified forage harvester was discussed by Dale O. Hull, Vern Lundell and W. D. Caldwell.

The session was addressed by ASAE president, Ivan D. Wood, on the subject "New Frontiers for Engineers." The section business meeting closed the forenoon session.

The afternoon was devoted to a field tour which included the Dannen Research Farm and two other farms in the area.

Rocky Mountain Section Meets in Wyoming

THE Rocky Mountain Section of the American Society of Agricultural Engineers will hold a meeting on the campus of the University of Wyoming at Laramie on April 10 and 11. The meeting will open on the forenoon of April 10 with a welcome from Dr. H. M. Briggs, dean, college of agriculture, University of Wyoming, and Guy O. Woodward, chairman of the Rocky Mountain Section. The technical program for this session will begin with a talk on correction of harvesting losses in small seeded legumes by Clarence F. Becker of the agricultural engineering staff of the University of Wyoming. R. D. Barmington, associate research engineer, Colorado A. & M. College, will follow with a talk on the mechanization and production of sugar beets. A report on soil moisture research in the production of sugar beets will be presented by W. M. Miller of the University of Wyoming agricultural engineering staff.

The afternoon program of the same day will open with a discussion of irrigation problems and requirements of mountain meadows by B. R. Tomlinson, irrigation engineer working cooperatively with the USDA and the University of Wyoming. This will be followed

(News continued on page 264)

This Oliver Cotton Harvester employs a complete Link-Belt screw conveyor for transfer of cotton from cleaning chambers to inclined discharge elevator.

There's no substitute for "total engineering" in screw conveyors

LINK-BELT integrates all components to give you the right screw conveyor for your machines

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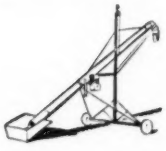
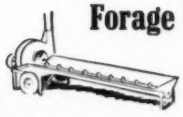


Grain loaders



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NEWS SECTION (Continued from page 262)

by papers presented by agricultural engineering students representing three student branches of ASAE, namely, at Colorado A. & M. College, Utah State Agricultural college and New Mexico A. & M. College. Awards for these papers will be made following their presentation by J. W. Borden of the Eversman Mfg. Co. The afternoon session will close with the Section business meeting which will include the selection of officers, and the Section dinner will be held in the evening.

The program for April 11 will be confined to the forenoon and will open with an address on the future of irrigation in agriculture by J. E. Christiansen, dean, school of engineering and technology, Utah State Agricultural College. This will be followed by three technical papers, the first by C. W. Lauritzen, Soil Conservation Service, on methods and costs of irrigation canal lining, the second on results of experiments in irrigation by V. E. Hansen, Utah State Agricultural College, and the third on sprinkler irrigation by A. W. McCulloch, president, Irrigation Equipment Co.

Pennsylvania Section Meeting

THE spring meeting of the Pennsylvania Section of the American Society of Agricultural Engineers will be held on the campus of Pennsylvania State College, April 23 and 24, with headquarters in the agricultural engineering building.

The opening program on the afternoon of April 23 will be devoted to the general theme of communicating ideas and information to others. Homer Martz of Radio Station KDKA will tell how to make an effective radio talk. How to interest farm readers will be discussed by M. C. Gilpin of *Pennsylvania Farmer*. How to stage a TV performance for a farm audience is the subject of Biron Decker, Erie County vo-ag supervisor. B. A. Jones of Ethyl Corp. will tell how to make worth-while slides.

The program will be concluded with two technical papers, the first by J. B. Stere of C. A. McDade Co. on the operation of a new type of electric farm motor, and the second on home processing of grains and feeds by L. S. Singley, West Penn Power Co.

The Section dinner will be held in the evening with C. G. Burress of Pennsylvania State College presiding. Reports of ASAE Student Branch activities at Penn State will be reported by four members and officers of the Branch. Robert Struble of the Brandywine Valley Assn. will address the group on how teamwork builds a better valley.

The forenoon session of April 24 will open with a talk comparing farm machinery in India now and 3,000 years ago by Shunil E. Roy, a student of Penn State. The remainder of the forenoon program will discuss various research projects in progress at Penn State, with J. E. Nicholas discussing heat control in electric sockets; H. V. Walton, durability of paints in farm use, and E. F. Olver and A. W. Clyde, new techniques in grain drying.

A business meeting will conclude the forenoon session, and the afternoon will be given over to an inspection trip to the Belleville Plant of the New Holland Machine Division of The Sperry Corp.

Ohio Section Meeting

MORE than 90 members and guests of the Ohio Section, American Society of Agricultural Engineers, met Saturday, March 7, at Coldwater, Ohio, for a combined inspection trip and technical meeting. Assembling at the plant of the New Idea Division, Avco Corp., the group toured its manufacturing setup from foundry to display floor. Lunch was served at the Methodist Church, after which the group convened at the city hall for a short technical session and business meeting.

Thomas P. Christen, Jr., chairman of the Section, presided over the short business session. A proposal to present a plaque or other evidence of service to each chairman of the Section was approved. Chairman Christen announced that the next meeting of the Section would be held as a joint meeting with the Michigan Section, at Toledo, Ohio, May 9. He then turned the meeting over to George B. Hill, director of engineering, New Idea Division, Avco Corp., and program chairman for the meeting, who introduced the speakers.

John Babcock, sales promotion manager of New Idea, addressed the Section on the question "Are Our Farms Overmechanized?" He indicated that haphazard investment in a wide variety of farm equipment to mechanize a broad range of small-scale operations on a highly diversified farm could result in an investment cost which would be needlessly high and out of proportion to use values. He recommended that farmers carefully plan their over-all operations on a business basis, recognizing and evaluating production costs, and avoiding costly duplications such as are involved in equipping a farm to handle forage in several different ways.

Bruce K. Tice, assistant director of engineering for New Idea, talked on problems involved in developing a new piece of farm machinery, illustrating his points with examples encountered in the development of an automatic wire tie for a baler.

A progress report on small grain harvesting studies by William H. Johnson, research engineer, Ohio State University, dealt largely with cylinder losses, as influenced by crop varietal characteristics and by design and adjustment factors. He pointed out that the results presented require careful interpretation and do not cover all the factors involved in harvesting losses. As an example, he mentioned the fact that the wheat variety which threshed most completely in passing the cylinder was also the one most subject to field shattering, among the four varieties included in this part of the study.

Conferences on Hydraulics of Soil Conservation Structures

THREE training conferences on the hydraulics of soil conservation structures were held at the St. Anthony Falls Hydraulic Laboratory of the University of Minnesota on March 24, 25, and 26; March 31, April 1 and 2; and April 7, 8, and 9. General subjects covered at these sessions included the characteristics of the hydraulic jump, the principles of sediment transportation, and the results of drainage experiments in Minnesota. The methods of design of such soil conservation structures as the straight drop spillway, the box inlet drop spillway, the closed conduit or drop inlet spillway, and the SAF stilling basin were fully explained. The explanations were made by means of lectures, motion pictures, and actual demonstration of good and poor practices using flowing water in the Laboratory demonstration channel. The attendance at each session was limited to fifteen so each person could "get his hands wet" during the demonstrations. The conference closed with a trip through the Laboratory to observe the wide variety of fundamental and applied research conducted there. Although these conferences are conducted primarily for Soil Conservation Service engineers, attendance is not limited to them and at past sessions a number of college professors, engineers from other federal departments, and engineers from several state conservation departments have attended. It is anticipated that additional conferences will be held in the future. The conferences were directed by Fred W. Blaisdell, Soil Conservation Service project supervisor at the St. Anthony Falls Hydraulic Laboratory, who was assisted by Charles A. Donnelly, SCS hydraulic engineer, Philip W. Manson, professor of agricultural engineering, and Alvin G. Anderson, assistant professor of hydraulics.

Concrete Agricultural Pipe Featured at Meeting

MUTUAL interests of the U.S. Bureau of Reclamation and of manufacturers in progress in the application of concrete agricultural pipe were featured in the third annual convention of the American Concrete Agricultural Pipe Association, February 24 and 25, at Dallas, Texas.

Representatives of the Bureau addressed the manufacturers on technical items relating to concrete pipe and on bureau of reclamation specifications for concrete pipe.

Howard F. Peckworth (Member ASAE), managing director of the Association, reported that mutual problems of the Bureau and members of the Association were brought nearer to solution in a committee meeting of representatives of the two groups, in which a spirit of understanding and cooperation prevailed.

NEWS OF ASAE MEMBERS

HARRY F. CLOFT, who has been serving as office salesman of the Dow Chemical Co. in Boston, Mass., was recently appointed agricultural chemical salesman for the New England territory of the company.

W. H. DICKERSON, JR., who has been farming at Willis, Va., has recently joined the agricultural engineering staff of West Virginia University, Morgantown.

PAUL E. FISCHBACH, who has been serving as agricultural development agent for the Central Nebraska Public Power and Irrigation District at Minden, recently resigned to accept appointment as district extension irrigation engineer of the University of Nebraska at Lincoln.

M. M. JOHNS recently resigned as director of the farm supply services of the Southern States Cooperative, Inc., to go into business for himself. He has organized the Johns Equipment Co. at Farmville, Va., which will act as manufacturer's representative and distributors of quality specialized farm equipment.

HERBERT E. SCHLEIDER is now connected with the Central Texas Irrigation Engineering Co. at Waco as partner and engineer. His activity includes consulting work in agricultural engineering and agricultural contracting.

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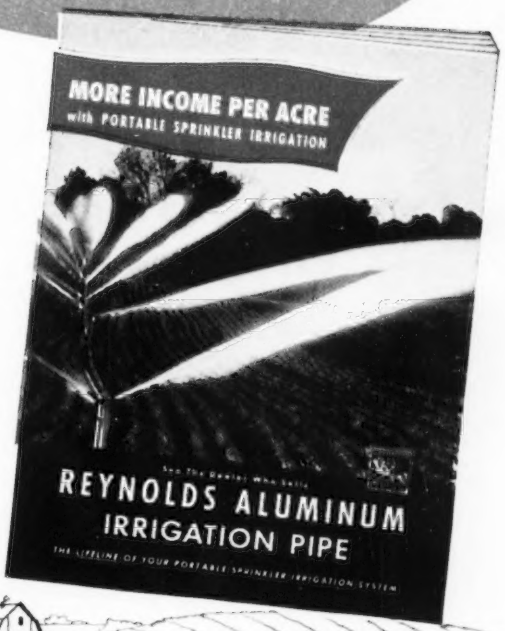

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Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

ADRIAN, PAUL A. — Agricultural engineer, American Crystal Sugar Co., Boston Bldg., Denver, Colo.

BERGEMANN, JOSEPH A. — Layout draftsman, J. I. Case Co., Racine, Wis.

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PRINGLE, FRED F. — Branch manager, R. M. Wade & Co., 532 First Ave., S., Seattle 4, Wash.

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SCOTT, ADAM F. — Methods engineer, Ewa Plantation Co., Ewa, Hawaii

THOMAS, J. HARVEY—Farm service engineer, Central Illinois Light Co., 316 S. Jefferson Ave., Peoria 2, Ill.

WARD, KENNETH A.—2nd Lt., U.S. Air Force

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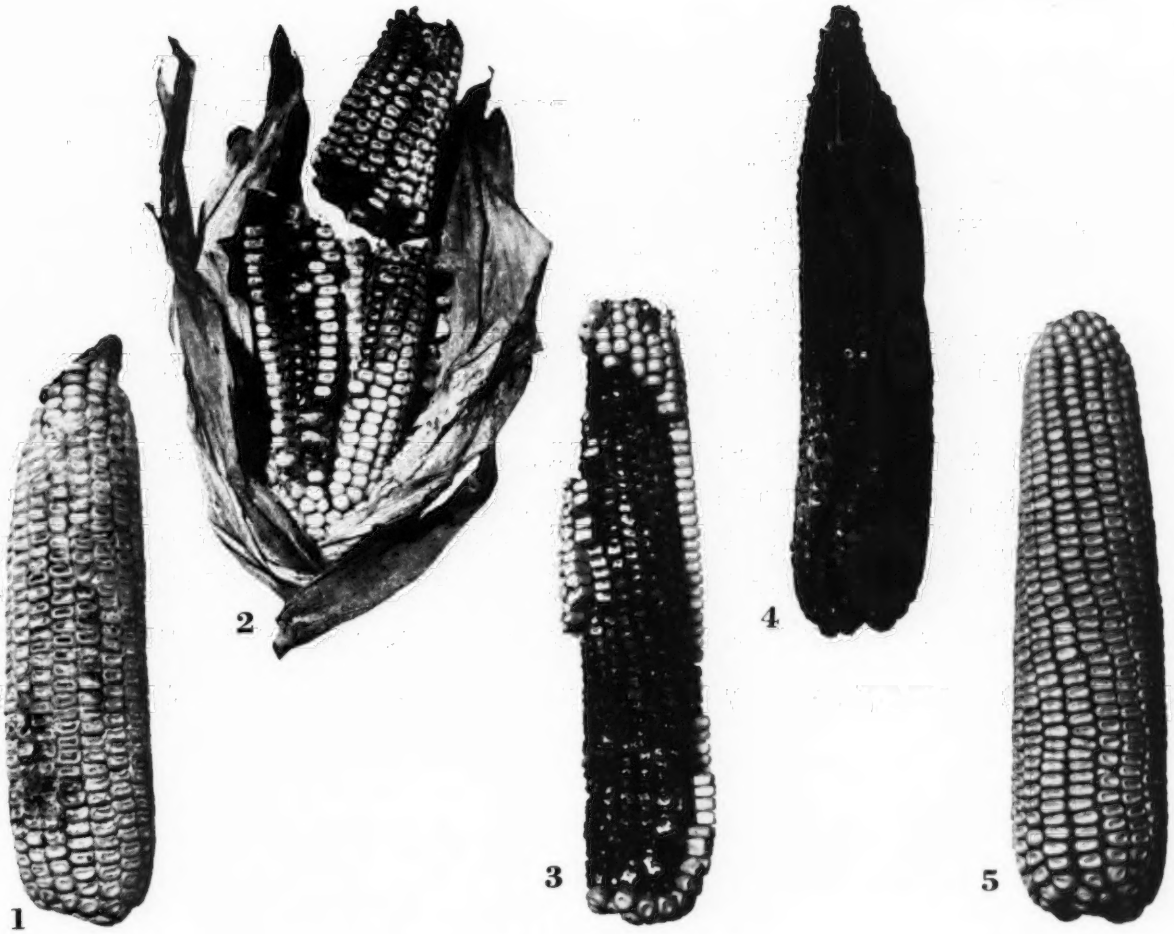
ERWIN, EDGAR E., JR.—Field engineer, Oxford Paper Co., 111 Knox St., Rumford, Me. (Associate Member to Member)



How many of these in the next crop?

1 **Spoilage in storage** is high when too much moisture is left in corn, or when rain and snow get into the storage unit after the corn is stored.

2 **Field losses** are severe when corn is field dried. Stalks are easily broken by storms, mechanical harvesting is difficult. Early snows or prolonged wet weather means corn sometimes spends part of the winter in the field, with losses as high as 20%.

3 **Rodents** eat or contaminate about 65 million dollars worth of corn each year.

4 **Lightning and fire** account for a large percentage of the 300-600 million bushels of corn lost annually.

5 Here's an ear that means more profit for the farmer. The crop was harvested when stalks were erect and sound, dried right away with a mechanical dryer, then stored in a weathertight, fireproof building of steel that rodents couldn't eat through.

That's how steel buildings and dryers help reduce waste. And here's how the special Armco Steels in this equipment help add to profits: In dryers, Armco Stainless Steel and Armco ALUMINIZED Steel assure high heating efficiency and resist combinations of heat and corrosion. In steel buildings, Armco ZINCGRIP assures long protection against rust.

Fill in and mail the coupon below for more information on this equipment that will soon save enough to pay for itself.

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Please send me:

- ☐ Further information on modern corn drying methods
- ☐ Names of portable crop dryer manufacturers
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$700 saved...

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STOW flexible shafting

courtesy IOWA MFG. CO.

That's the experience of the IOWA MFG. CO., manufacturers of this super-tandem crushing plant which employs a 1¼" STOW power drive shaft, operating at 800 RPM. A centrifugal clutch relieves sudden starting loads. Use of the flexible shaft as shown permits a swing of up to 90 degrees either side of the center line.

This is another fine example proving the efficiency, the practicability of STOW flexible shafting.

Why not consult with STOW engineers on your next power transmission problem. You'll find that Stow flexible shafting can really do a job for you!

***Write today** for this free bulletin 525 and Torque Calculator, containing complete data on STOW flexible shafting. No obligation, of course.*

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39 SHEAR ST. BINGHAMTON, N.Y.

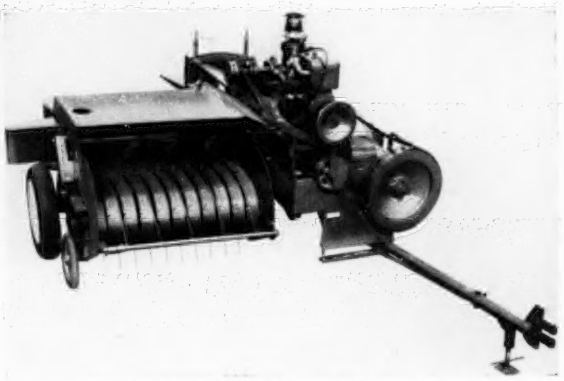
NEWS FROM ADVERTISERS

New Products and Literature Announced by AGRICULTURAL ENGINEERING Advertisers

Precompression Action Baler

New Holland Machine Co., New Holland, Pa., recently announced a new low-cost automatic twine-tying baler designed particularly for the farmer with smaller hay acreages. Outstanding feature of the new model 66 is its precompression action.

The precompression action, part of the new pickup and feeding action, gives the baler a capacity of up to six bales a minute. A 47½-in wide pickup, spring supported to "float" over the ground, handles full-size windrows. An auxiliary wheel guides the pickup over field contours. Adjustable windguards hold the hay to the power-driven pickup for fast feeding. The feeder arrangement keeps a positive pressure on the hay regardless of the size or density of the windrow. A rigid, open-end auger and a spring-supported floating bottom moves the hay quickly and evenly into the special precompression chamber. In the precompression action a special plunger compresses the hay before it reaches the wadboard. Then the wadboard built in horizontally to add to the machine's compactness, works on precompressed instead of loose hay, speeding up the baling action.



The New Holland Model 66 automatic twine-tie baler

Other major features include "bird's-eye" visibility which lets the operator look over the 4-ft high baler to watch pick-up, tying, and baling action without moving from the tractor seat. Low center of gravity and wide wheel tread, 7 ft 5 in, give good stability on hilly hayfields. Dual wheels, available as optional equipment, can be mounted alongside standard wheels for extra tread in soft ground. Weighing approximately 2500 lb and powered by a 2-cylinder engine, the Model 66 produces bales of sliced hay measuring 14"x 18 in and adjustable in length to 30, 36, or 42 in.

New 2-3 Plow Tractor

International Harvester Co., Chicago, Ill., has announced a new 2-3 plow tractor — the McCormick Farmall Super H. It has 14 per cent greater power at the drawbar and up to 26 per cent faster field speeds. The manufacturer states that the new tractor will pull a three-furrow regular moldboard plow in most soils

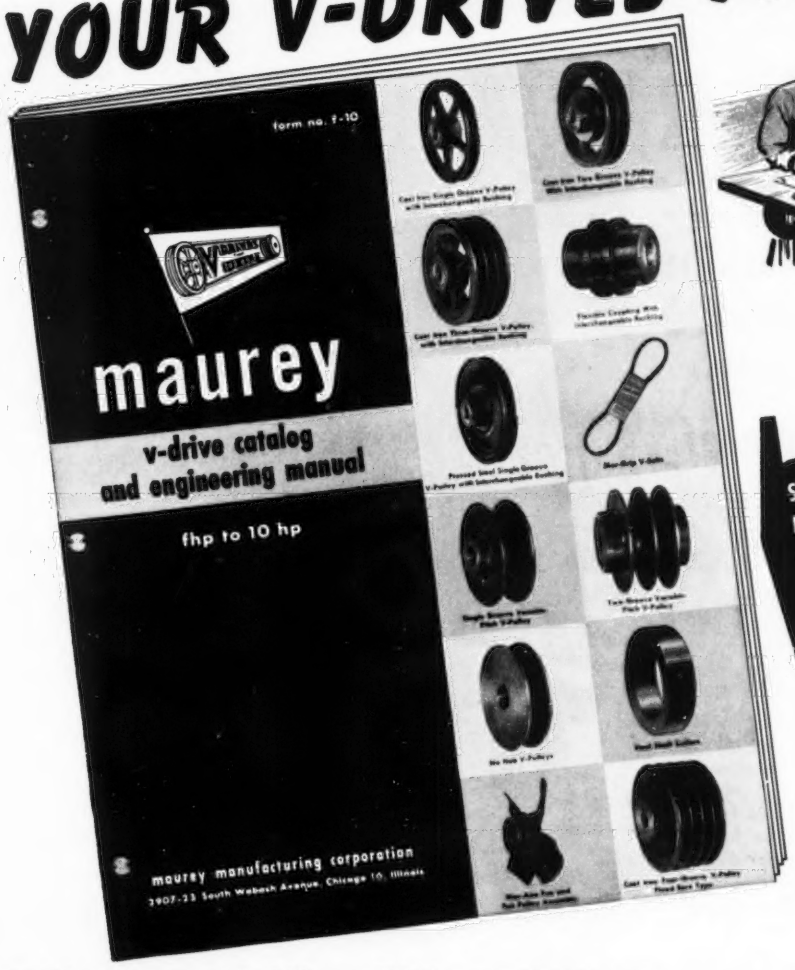
The new Farmall Super H tractor

or a four-row cultivator. Self-energizing, double-disk brakes are included in a list of 21 major improvements in the new tractor. The full line of McCormick equipment that works with the Farmall H will fit the new Super H.

(Continued on page 270)

For Your Product Data . . .

THIS BOOK BELONGS IN YOUR V-DRIVES FILE



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NEWS FROM ADVERTISERS

(Continued from page 268)

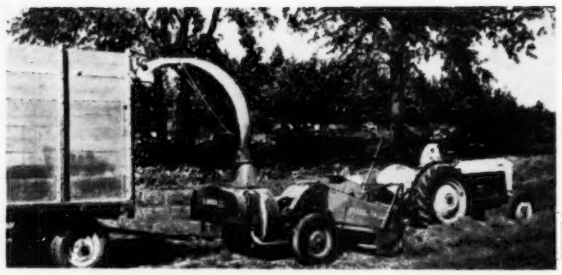
Forage Harvester

Dearborn Motors Corp., Birmingham, Mich., has added to its line a forage harvester, designed to chop and load up to 15 tons of hay or row crop silage per hour.

Available in both PTO and engine-driven models, the Dearborn forage harvester will pick up windrowed crops or cut standing row crops. Chopped material is discharged into a trailing wagon or truck driven behind or beside the harvester.

Forage material may be cut in lengths from ⅜ to 4 in by changing drive sprockets and removing two or three of the four knives. The cutterhead drive mechanism is protected by a slip clutch, which is adjustable for varying crop conditions. The drive mechanism can be reversed from the tractor seat to clear out clogging due to overloading.

The engine-driven model is equipped with a 31-hp, four-cylinder engine. The PTO driven model has an ASAE standard hitch.



Dearborn forage harvester with trailed wagon

Only seven feet wide the havester passes easily through gates and narrow lanes. Controls, which can be operated from the tractor seat, are adjustable for length as well as height, making them accessible to the operator.

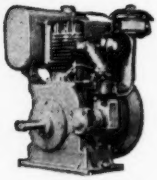
POWER

to Fit the Job . . . to Fit the Machine WISCONSIN-POWERED *"Steel Squirrel"*

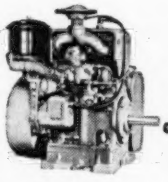
Now one *man* does the work of several, pruning, thinning, picking or wiring trees. It's the "Steel Squirrel", built by Blackwelder Manufacturing Co., Rio Vista, Calif., and powered by a Model AKN, 6 hp. single-cylinder Wisconsin Heavy-Duty Air-Cooled Engine.

Over 500 manufacturers of all types of equipment in many fields rely on Wisconsin Engine power . . . *dependable power* brought about by Wisconsin Heavy-Duty Engine features. For example, tapered roller bearings at both ends of the shaft hold shaft and housings concentric, making closures more effective. Side and end play are taken up . . . bearing failure is unheard of. In addition, Wisconsin Engines offer the user foolproof air-cooling, heavy-duty construction throughout *plus* light weight and extreme compactness for easy adaptation to existing machine design. Complete your power file with "Power Magic" covering detailed information about all 4-cycle single-cylinder, 2-cylinder and V-type 4-cylinder models, 3 to 36 hp.

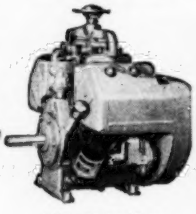
3 to 6 hp. single-cylinder models.



6 to 9 hp. single-cylinder models.



7 to 14½ hp. 2-cylinder models.



15 to 36 hp. V-type 4-cylinder models.

WISCONSIN MOTOR CORPORATION

World's Largest Builders of Heavy-Duty Air-Cooled Engines

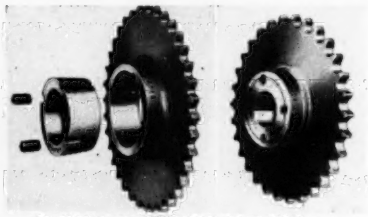
MILWAUKEE 46, WISCONSIN

A 7481-1½-1

Taper-Lock Sprockets

A new line of taper-lock sprockets and roller chain is being introduced by Dodge Mfg. Corp., Mishawaka, Ind. One of the chief advantages claimed for the new products is that they bring a new "off-the-on shelf" availability to roller chain drives, which is achieved by the application to sprockets of the taper-lock principle, now in use in V-belt, coupling, conveyor pulley and silent chain installations.

Taper-lock sprockets and bushings eliminate the reboring of sprockets to fit shafts, and it is



Exploded and assembled views of Dodge taper-lock sprockets

unnecessary to turn and grind shafts to get a tight fit, since the taper-lock sprocket not only is keyed to the shaft, but also grips it with a firmness of a shrunk-on fit, yet when the sprocket is to be replaced it comes off easily and the bushing may be reused. These taper-lock sprockets are compact as they have no flange and no protruding parts, and they occupy no more space on the shaft than standard sprockets.

Wheel-Controlled Disk Harrow

International Harvester Co., Chicago, Ill., has announced a new McCormick wheel-controlled No. 35-A tandem disk harrow, designed to provide controlled penetration, easy turning, and fast transport. The wheels are used to gage desired penetration in any soil. They can also be regulated to place the full

McCormick 35-A wheel-controlled disk

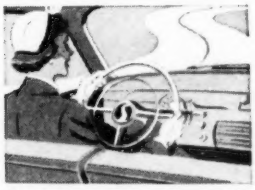
weight of the harrow on the disks for maximum penetration in heavy soil. Elimination of the need for angling and de-angling saves time and labor on turns and when crossing grass waterways. In transport position, the disk raised on its wheels can be moved from job to job at tractor road speeds. The disk is available in 7, 8, 10, and 12-ft sizes to match tractors of from two to five-plow power.

(Continued on page 272)

Saginaw Steers the Nation!

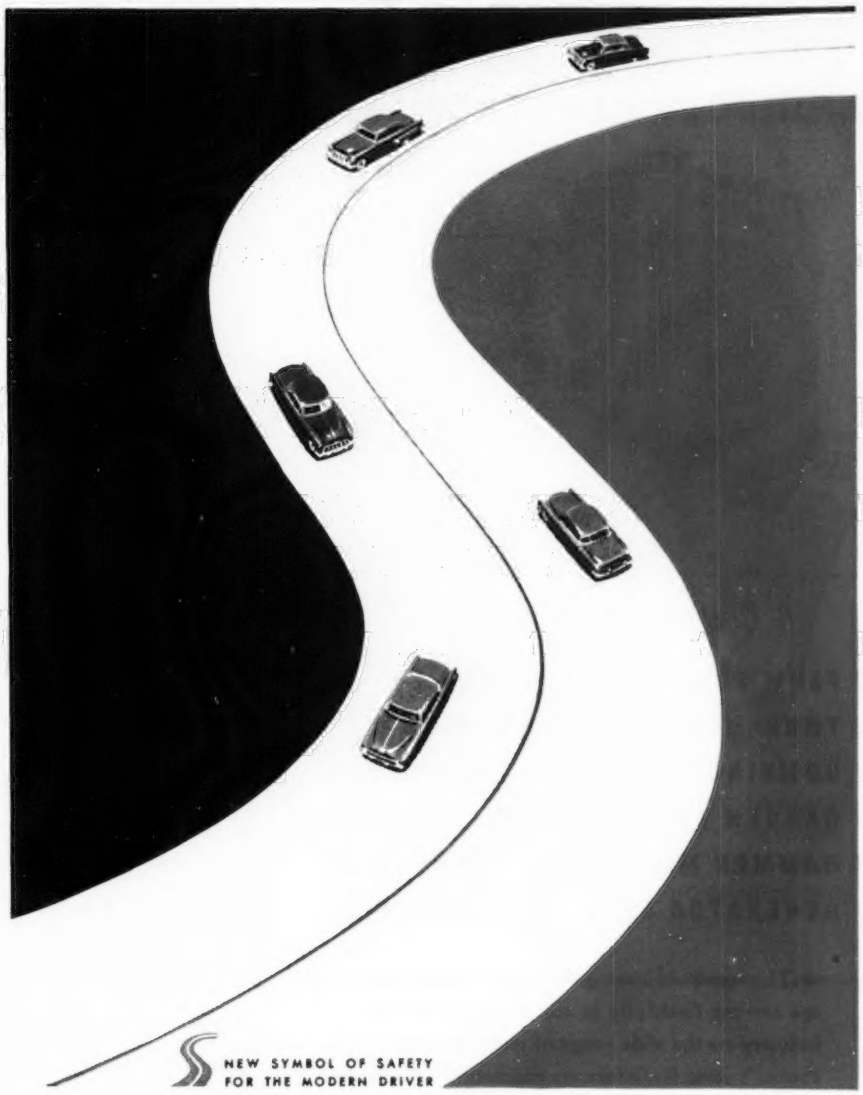
America's favorite—more than 35 million automobiles over the years have been Saginaw-steered.

Farm favorite, too — Saginaw also brings "automobile" steering ease to many makes of farm tractors.



Saginaw brings you new driving safety — Saginaw Power Steering has the normal "feel of the road".

Greater control in any emergency — Saginaw Power Steering absorbs shocks, prevents loss of control.

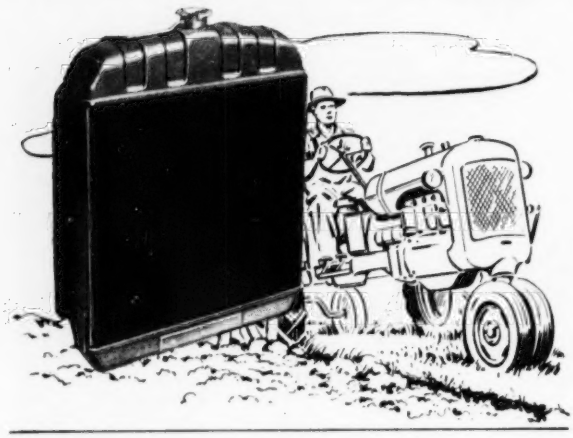


Saginaw

POWER STEERING

Now Saginaw—world's foremost manufacturer of steering equipment—brings you the greatest advance of all: Saginaw Power Steering. It's the *only* power steering that gives you incredible driving ease *plus* the normal "feel of the road" for extra safety! Already Saginaw Power Steering is featured on six 1953 automobiles—but that's only the beginning! Soon it may bring unheard-of handling ease to *tractors*, too . . . another of Saginaw's many work-saving contributions through the years to help take the fatigue out of farming. Saginaw Power Steering is just one of many precision products developed and manufactured by *Saginaw Steering Gear Division*, General Motors Corporation, Saginaw, Michigan.

YOUNG Serves the AGRICULTURAL INDUSTRY



Cooling Equipment for:

- ✓ FARM TRACTORS
- ✓ THRESHERS
- ✓ COMBINES
- ✓ GARDEN TRACTORS
- ✓ HAMMER MILLS
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- ✓ PUMPS
- ✓ SPRAYERS
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- ✓ And Other Specialized and Routine Needs

● Thousands of Young Automotive Radiators are serving faithfully in the vital agricultural industry on the wide range of machinery listed above. Young Radiators are engineered for the specific job . . . by specialists in Heat Transfer Products for over two decades . . . to give maximum efficiency and service. They are available in sheet metal, cast iron, or welded steel construction . . . in stationary, removable one-piece, or removable section cores. Young Automotive Radiators also provide efficient, economical cooling for cars, trucks, busses, locomotives and stationary engines.

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NEWS FROM ADVERTISERS

(Continued from page 270)

Floor Design Manual

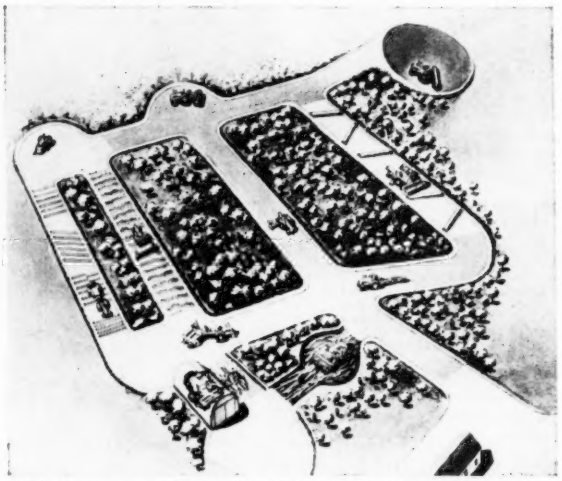
Portland Cement Assn., 33 W. Grand Ave., Chicago, Ill., recently issued a new bulletin, entitled "A Design Manual for Concrete Farm Floors." This has been made available primarily for engineers who prepare farm building plans. It provides data, illustrations and explanatory text which simplify the work of designing reinforced concrete floors and roofs for farm buildings. Precast concrete joist, concrete block joist, and concrete slab are the structural units emphasized.

Tractor Test Track

Massey-Harris Co., Racine, Wis., has installed on its experimental farm a test track where farm equipment absorbs more punishment in hours than ordinary farm operation could give it in months. Object of the tests is to maintain quality in farm equipment by thoroughly checking engineering design and structure of parts under actual operating conditions.

Some of the tests provided are as follows: The obstacle courses, made up of rock-ribbed cobblestone roads and a series of steel rails, jolt and jar every nut, bolt and cross brace on machines. Each machine is disassembled after this run and parts are checked for strain and wear. If a part doesn't stand up to rigid requirements, it goes back to the engineering department to be redesigned.

A dust tunnel outdoes any natural sand storm. Oil seals, gaskets, air cleaners, transmissions, clutches and other parts are choked with barrel after barrel of swirling abrasive dust and sand particles. Wheels, bearings, brakes and ignition are checked for proper protective sealing. A three-foot-deep water bath and a thick gumbo mud bog course provide severe tests for wheels, bearings, brakes, and ignition. Adaptability to side hill farming operations is tested by a ramp and steep grades. All combines traveling through these balance courses must measure up to rigid standards with the grain tanks empty. With the grain tank even one-half full, balance would be greatly improved and become almost perfect.



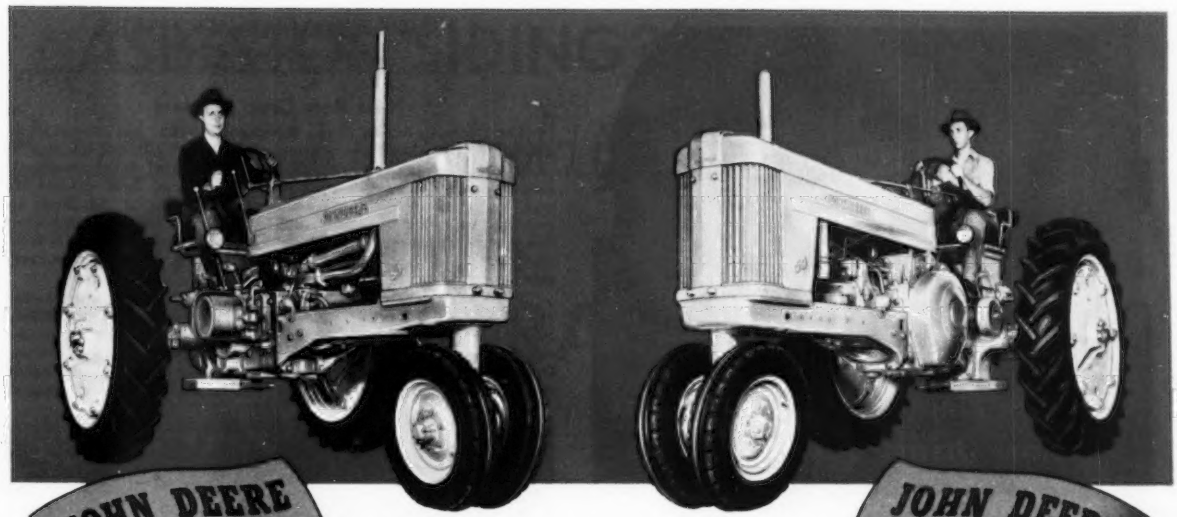
Bird's-eye view of Massey-Harris farm equipment test track layout

On a levee obstacle course, giant self-propelled combines twist and pound their way over simulated rice levees, then splash through axle-deep water to duplicate the conditions of rice farming they will meet.

No matter what any specific farm condition may be like — rough, hilly, dusty, muddy — there's a greatly magnified version of it on the Massey-Harris test track.

As an added safeguard for quality, machinery and implements are put to work on the experimental farm under normal field conditions, and are tested there with the world's most scientific electronic instruments. Wires, which are attached to various parts of the machinery being tested, lead to a recording instrument which is transported by a truck alongside the machine. Stresses and strains are recorded in graph form to give an accurate and complete record for engineers to study.

(Continued on page 274)



JOHN DEERE HEAVY-DUTY 2-PLOW 50

THESE HUSKIES ARE EQUIPPED WITH DURKEE-ATWOOD V-BELTS

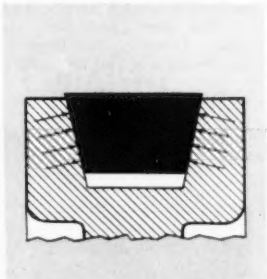
JOHN DEERE HEAVY-DUTY 3-PLOW 60

Proved in field service on the famous John Deere Model "B" and "A" tractors, Durkee-Atwood V-Belts are factory equipment on their successors, the John Deere heavy-duty 2-plow "50" and heavy-duty 3-plow "60."

Durkee-Atwood V-Belts are meeting the exacting demands of John Deere Tractor engineers. As a component of the new "50" and "60," they are contributing to their outstanding performance, dependability and efficiency.

STRAIGHT SIDEWALLS MAINTAIN FULL GROOVE CONTACT

Durkee-Atwood V-Belts are manufactured with straight sidewalls to maintain full groove contact at all times giving positive drive action. Straight sidewalls reduce slippage and assure smooth, efficient power transmission. The load is distributed evenly over the entire thickness of the belt giving it longer life.



DU PONT "CORDURA"® RAYON CORDS ARE USED FOR D-A V-BELTS

Cords of high-tenacity "Cordura"® Rayon give Durkee-Atwood V-Belts longer life, less stretch, and greater shock resistance. Use of this revolutionary new cord material is a noteworthy contribution to their improved performance.

DURKEE ATWOOD V-BELTS

DURKEE-ATWOOD CO.

Dept. AE-4 Minneapolis 13, Minn.

Suppliers of original equipment V-Belts for major manufacturers of:

TRACTORS • COMBINES • MOWERS • HAY RACKS • FORAGE HARVESTERS
CORN PICKERS • WINDROWERS • CHOPPERS • COTTON PICKERS

Form No. 557

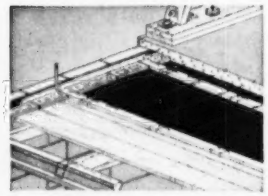
Engineered

Concrete Floors Protect Buildings Against Disastrous Farm Fires

Agricultural engineers can help reduce the crippling losses of farm fires by including concrete floors in their plans for barns, multistory poultry houses and homes.

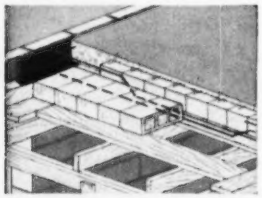
Protection from this danger is especially important in homes, where sleeping quarters often are above heating plants, and in barns, where hay or feed is stored above livestock.

Concrete floors keep fire from spreading up or down, thus protecting families, animals and machinery. There are three principal types:



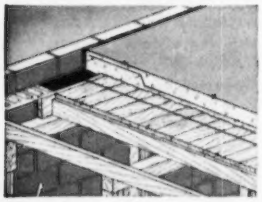
PRECAST CONCRETE JOIST FLOORS

are ideal for those buildings not subjected to concentrated loads such as heavily loaded trucks or wagons. Construction is similar to framing wood floors and the forming for the covering slab is simple.



CONCRETE BLOCK JOIST FLOORS

are easy to build and require no special equipment. Using 4-, 6- or 8-in. block as filler, you get a corresponding total floor thickness of 6⅛, 8⅛ and 10⅛ in. when the concrete topping has been added.



REINFORCED CONCRETE SLAB FLOORS

are economical for the loads and spans encountered in farm buildings. They are especially adaptable to drive-in type buildings because they are rigid and can take vibrations and heavy loads.

Design data and information on concrete floors are included in an illustrated booklet, "*A Design Manual for Concrete Farm Floors.*" Write for a free copy. Distributed only in U.S. and Canada.

PORTLAND CEMENT ASSOCIATION

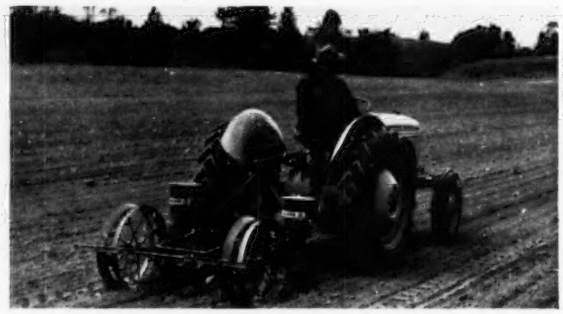
Dept. A4-1, 33 West Grand Avenue, Chicago 10, Illinois

A national organization to improve and extend the uses of portland cement and concrete . . through scientific research and engineering field work

New Row Crop Planters

The Dearborn Motors Corp., Birmingham, Mich., has announced the addition of three new corn planters — checkrow, drill and hill-drop, to its farm equipment line. The planters are designed for planting corn, beans, peas, sorghums and other row crops, and all three are full lift-type implements designed to attach to the Ford tractor. No levers are required to throw these new planters out of gear. They are ground-wheel driven and stop planting when lifted. A selection of seed plates is available for use with various sizes and kinds of corn. Plates also are available for planting other crops.

The hitch has been redesigned to obtain even planting in both rows and maintain even depth through the action of the Ford tractor hydraulic mechanism. The new hitch, in conjunction with the Ford tractor's constant-draft control, compensates for changes in weight of the seed and fertilizer load while planting, and eliminates the need for gage wheels when using the fertilizer attachment. The fertilizer attachment gives an



Dearborn drill planter, representative of new drill, hill and check-row models

almost vertical drop for fertilizer through the full range of row widths. Fertilizer hopper capacity has been increased to 85 lb per hopper.

Press wheel width has been increased to 7 in and the diameter to 24 in for more positive drive. Row width adjustment can now be made from 28 to 44 in with the drill and hill-drop planters, and when drilling with the check-row planter. Adjustment is from 38 to 44 in when checking with the check-row planter.

Available attachments, in addition to the fertilizer distributor, include a disk marker, disk openers, hook marker, wheel bands, 8-in shoes and hopper extensions.

Dual-Purpose Disk

Dearborn Motors Corporation, Birmingham, Mich., is producing a fold-over disk harrow which can be used as a tandem disk harrow or as a bush and bog harrow.

The front gangs have eight notched 20-in disks, spaced 9 in apart. There are ten 18-in disks on the rear gangs, spaced at 7¼ in. Both front and rear gangs are permanently set at 20-deg angles

Dearborn fold-over disk harrow

for most efficient performance in all types of soil and field conditions. Used as a bush and bog harrow, there are 90 lb of weight on each blade. The cutting width is 6 ft in either position. The frame is structural angle and channel steel, arc welded. Blades are heat-treated and all bearings are heavy duty white iron with pressure grease fittings. The implement weighs approximately 720 lb.

Ford tractor hydraulic touch control lifts and lowers the harrow and regulates the working depth of the implement. A three-position assembly on the frame allows the rear disks to be raised or lowered in relation to the front gangs for proper working depth. The tractor leveling crank adjusts the implement to fit varying ground contours.

(Continued on page 276)

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3 reasons why you should insist on Johns-Manville SMOOTHGRAIN

1 Superior Styling . . .

Viewed from any angle, Smoothgrain has a rich, grained texture, yet its surface is smooth and resistant to soiling. Colors are beautifully styled in deep autumn shades or smart springtime pastels. The pleasing grained texture and lasting colors are achieved by colored ceramic granules deeply embedded in the asbestos cement siding.

2 Outstanding Quality . . .

The J-M manufacturing process gives Smoothgrain Siding dimensional stability—resistance to shrinking—tight joints that won't open up later on. Furthermore, the built-in texture is so striking, that you can hardly see face nails and vertical joints.

3 Best Known Name . . .

The Johns-Manville name has been the standard of quality for 95 years. Color ads in national magazines and the Bill Henry Radio News Program are constantly building preference for products which carry the J-M name.

For full information **about Smoothgrain Asbestos Siding and other J-M Building products, write Johns-Manville, Box 60, New York 16, N. Y.**

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get the *SUPER SHEET* bearing this "Seal of Quality," signifying at least 2 ounces of zinc per square foot.

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☐ Directions for Laying Galvanized Sheets
☐ Metallic Zinc Paint Protects Metal Surfaces

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Address_____
City_____

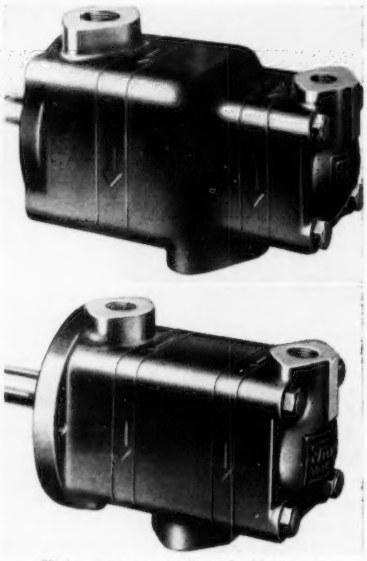
NEWS FROM ADVERTISERS

(Continued from page 274)

New Vane-Type Double Pumps

Vickers, Inc., Detroit, Mich., announces two new double pumps, series V-2200 and V-3200, for mobile applications where two independent hydraulic power sources are required. Both series are compact and each consists of two vane-type pumps in a single housing, driven by a common shaft. This provides the required independent systems and, in addition, significant savings in space and costs. Improved operational characteristics and lower maintenance costs are also indicated.

The new double pumps are particularly applicable to materials-handling equipment and road and construction machinery for applications such as power steering in addition to the usual needs. Both series provide long service life with continuing high efficiency and low maintenance requirements. Their basic design is identical with Vickers' standard line of



Vickers' new vane-type double pumps

mobile pumps, with balanced pressure design and automatic adjustment of both radial and axial clearances.

Ten sizes of series V-2200 pumps are available, with any combination of 2, 5, 8 or 11-gpm delivery units. Series V-3200 pumps are made in 16 sizes, with a choice of a 2, 5, 8 or 11 gpm at the small end and a 12, 15, 18 or 24-gpm pump at the other. A choice of splined, threaded or straight keyed shafts and face, flange or foot mountings is available.

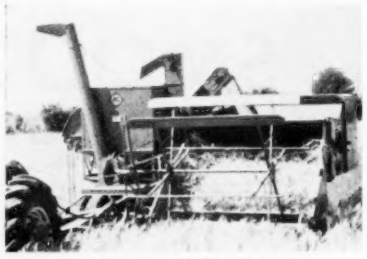
Installation drawings Nos. 157591 and 158073, on 8½ x 11-inch paper and punched for 3-ring binders, are available on request to M. J. Taup, manager, mobile products sales, Vickers, Inc., 1516 Oakman Blvd., Detroit 32, Mich.

Riveted Roller Chain Bulletin

The Chain Belt Co. has issued a new bulletin on the improved Baldwin assembly riveted roller chains, a chain which *it* says is as easy to couple or uncouple as a cottered chain. The book contains a graphic section of how the chain is made up to any length. Features of the chain and the Baldwin-Rex single-pin coupler link are illustrated and described. Assembly diagrams and charts for all size chains are presented as well as list prices and boxes assembly specifications. List prices, strengths, dimensions and weights of standard roller chain are also given. For a copy of this bulletin write Baldwin-Duckworth Div., Chain Belt Co., Springfield 2, Mass., and request Bulletin 52-2.

New Model All-Crop Harvester

Allis-Chalmers Mfg. Co., Milwaukee, Wis., has in production the Model 66 All-Crop harvester with 6-ft header and 66-in sickle bar. Basic design of this harvester remains as in the Model 60 but a wider header and other improvements are found in the new machine and attachments for it. A six-bat reel with heavier shaft and bracing is now standard equipment.



Allis-Chalmers All-Crop harvester

A new straw rack provides improved straw handling action. The straw travels over a series of three steps giving it an unusually rough ride. Six notched steel cross slats on the metal portion of the rack directly behind the cylinder help to keep straw moving in a wide thin blanket without bunching or backlashing. All three fishbacks are alike and shorter than before. A new cleanout door, easy to open, is located below the lower draper roll, giving ready access to the roll for cleaning if foreign matter or wrapping is encountered. The header is center suspended through a heavy-duty balance spring for better weight distribution on the lift mechanism. Auxiliary feed rolls for handling flax and many other crops are available as an attachment.

Automatic Wire-Tie Baler

The Oliver Corp., Chicago 1, Ill., has announced a new fully automatic wire tie baler, as Model 100. An "out-of-wire" signal system which automatically stops the engine when any of the four coils of ASAE Standard 14½-gage wire is exhausted is standard equipment on this baler.

A 9-in-diameter pickup cylinder lifts the leaves a few inches onto the low inclined elevator. New spring tines, mounted on six spring tine bars, pull a uniform carpet of hay over a

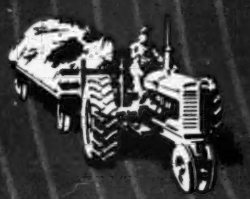
Oliver wire-tie baler

solid, smooth sheet-steel deck to the crossfeed mechanism. The pickup unit can be stopped from the tractor seat by means of a rope. The crossfeed mechanism includes a cleated, 2-ply rubber belt below the open-end auger which extends all the way to the bale chamber, and assures a constant and steady flow of hay to the force feeder. The Model 100 baler's new tying unit gives a short, firm holding knot of five full twists averaging only 1½ in in length. A new gear arrangement furnishing a 22-to-1 gear-reduction feature gives reserve centrifugal momentum to the flywheel for increased drive at peak loads, with an even load on the engine.

Bendix

Farm Tractor Brakes

the best solution to every Braking Problem



Automobile manufacturers, as well as truck and bus builders, have long recognized Bendix as braking headquarters for their industries. And today progressive tractor manufacturers are turning in increasing numbers to Bendix for the best solution to their individual braking problems.

There is good reason for this growing preference for Bendix Tractor Brakes. Nowhere else can be found comparable manufacturing facilities combined with an engineering experience that cover every major braking development in the past quarter of a century.*

Why not let Bendix farm tractor brake engineers help you find the best solution to your braking problems.

Your inquiry will receive prompt attention. Write for complete information.

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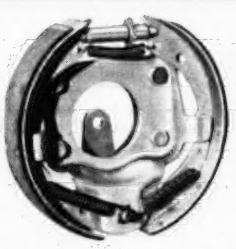
Bendix International Division, 72 Fifth Avenue, New York 11, N.Y. • Canadian Sales: Bendix-Eclipse of Canada, Ltd., Windsor, Ontario, Canada.



The Bendix heavy-duty farm tractor brake has powerful and positive holding action in both forward and reverse. Rugged design assures uniform performance day after day, under the most severe field and road work.

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FOR FARM AND INDUSTRY

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the BADGE of him who BELONGS

DESPITE the *presumption* it sets up, mere membership in the American Society of Agricultural Engineers is no *proof* of a man's high rank in technical talent. It does prove that he has met certain minimum requirements and has earned the esteem of colleagues who sponsored his application for membership.

But the Society emblem is *evidence* that native talent, be it great or small, is enriched by fraternity with the personalities whose minds fuse to form the pattern of progress in the methods and mechanics of agriculture. The wearer of the emblem waits not for the debut of an idea, but is present at its birth and helps to guide its growth.

Be you novice or veteran, your membership in the organized profession adds something to your efficiency, your vision, your influence as an individual engineer. The Society symbol on your lapel is token that you "belong". Wear it.

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NEW BOOKS

I REMEMBER, by Dexter S. Kimball. Cloth, 246 pages, 5½ by 8 in. McGraw-Hill Book Co. (330 W. 42nd St., New York City 36, N. Y.) $4.00.

This autobiography of a great leader in engineering and engineering education, a former dean of the college of engineering at Cornell University and a past-president of the American Society of Mechanical Engineers, is a warm and human portrait of one greatly admired and honored by a host of American engineers. The book presents two stories, one a revealing picture of the rise of a young man from apprenticeship in a machine shop to the deanship of a leading engineering school and the other a nostalgic and surprising account of America awakening to the miracles of the machine age. The late Dean Kimball's good-humored reflections and recollections reveal more than the stirring accomplishments of a leader in the field of engineering. They chronicle the genius of America, with its capacity for invention and production, and unfold a fabulous fifty years of industrial progress.

• • •

WILLIS HAVILAND CARRIER, Father of Air Conditioning, by Margaret Ingels. Cloth, 170 pages, 5½ x 8½ inches. Doubleday and Co. $2.50

A biography of an engineer by an engineer, this work records the character and ability of Carrier as a great inspirational leader and incidentally pictures much of the early history of air conditioning as an engineering and industrial development. The story is enriched by the fact that, in addition to being an engineer and a writer, Miss Ingels was closely associated with Carrier and his organization for the latter 33 years of his life, planned the biography before his passing, and during the last two years of his life had 96 interviews with him to make notes on his recollections. The personal side of the story is supplemented by a chronological table of events which led to modern air conditioning, covering the period from early work by Leonardo de Vinci in 1500, to a summary of the state of the industry in 1952. The whole engineering profession stands to gain inspiration and public understanding from this monument to one of its leaders.

• • •

DAIRY ENGINEERING (Second Edition), by Arthur W. Farrall. Cloth, xvii + 477 pages, 6 x 9 inches. Illustrated and indexed. John Wiley and Sons, Inc. (440 Fourth Ave., New York 16, N.Y.) $6.00.

First published in 1942, this text and reference as now brought up to date still deals with the subject as a help to the student and operator rather than as a guide to the advanced designer. It has been brought up to date on plant design, waste disposal, labor-saving methods, servicing of dairy equipment, sanitary standards for dairy equipment, and new dairy product handling processes. Chapters cover physical and chemical properties of milk; simple mechanical principles; power transmission; electrical power and equipment; hydraulics and pumping; heat measurement, transfer and control; steam and its use in the dairy; principles of refrigeration; insulation and cold-storage rooms; heaters — coolers, heat-exchange equipment, and milk-storage tanks; ice-cream freezing equipment; homogenizers; pasteurizing equipment; evaporating and drying equipment; can-washing and sterilizing equipment; bottle washers, fillers, and cappers; cream and butter handling equipment; cheese and casein plant equipment; equipment maintenance, and dairy plant design, layout, and utilization. Applicable basic data are given in an appendix.

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"... More than 6,000 of our employees are now participating ..."

MELVIN H. BAKER
Chairman of the Board, National Gypsum Company

"The Payroll Savings Plan for Bonds provides a convenient and profitable way for America's wage earners to save. Millions of Payroll Savers have become proud owners of homes purchased with Bonds bought this way. It also helps our national government with its problems of managing the public debt. We in National Gypsum urge the stimulation of the Payroll Savings Plan and are proud to report that more than 6,000 of our employees are now participating."

Here's another success story of a person-to-person canvass:

In the Wahoo (Nebraska) ordnance plant of the National Gypsum Company, employee participation in the Payroll Savings Plan was a very low 1.73%.

In September of last year, with the whole-hearted encouragement of top management, the 3,000 employees of Gypsum's Ordnance Plant organized to conduct a person-to-person canvass to put a Payroll Savings Application Blank in the hands of every employee.

90% of the employees signed up in the opening days of the campaign. By September 12th, employee participation was 93.7%. On October 2nd, participation was almost 97%—and still going up.

To quote from National Gypsum's printed report of the Payroll Savings campaign:

• "Did we use fancy charts! Did we use advertisements? Did we have long-winded meetings. Did we give prizes for production? The answer is No! We put the proposition squarely to the people, and we reported to the people once a week in bulletin form to let them know where they stood in relation to other departments as well as to the plant total. Once the spirit of competition and teamwork caught fire, once it became a matter of personal pride; a successful conclusion was only a matter of time and effort."

Justifiably proud of its sponsorship of the Payroll Savings Plan and the 97% enrollment of its employees, National Gypsum Company prepared a very interesting folder, "Bombs and Bonds for National Defense. The Savings Bond Program of the National Gypsum Company." Savings Bond Division, U. S. Treasury Department, Suite 700, Washington Building, Washington, D.C., will be glad to send you a copy. Read how easy it is to build *your* Payroll Plan to 90% or more participation.

The United States Government does not pay for this advertisement. It is donated by this publication in cooperation with the Advertising Council and the Magazine Publishers of America.

AGRICULTURAL ENGINEERING

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Through 15 years, under all kinds of conditions throughout the world, Rain Bird Sprinklers have proved their dependability in faultless, low-cost performance.

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If yours is a special irrigation problem, consult our research department now.

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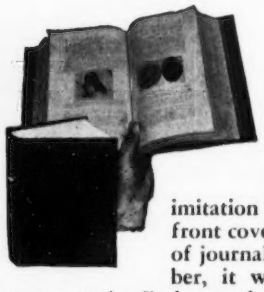

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Personnel Service Bulletin

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Joseph, Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. The Society does not investigate or guarantee the representations made by parties listed. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request. "Agricultural Engineer" as used in these listings, is not intended to imply any specific level of proficiency, or registration, or license as a professional engineer.

NOTE: In this bulletin the following listings still current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated.

POSITIONS OPEN — 1952 — OCTOBER — O-767-583, 785-591, 774-595. DECEMBER—O-797-597. 1953—FEBRUARY—O-907-605, 911-606, 7-501, 6-502, 10-503, 11-504. MARCH—O-50-505, 74-506, 82-507, 73-508, 99-509, 102-510.

POSITIONS WANTED — 1952 — NOVEMBER — W-823-144. DECEMBER — W-843-146, 832-148, 849-149, 866-150. 1953 — JANUARY—W-827-152, 884-154, 896-157. FEBRUARY—W-893-160, 895-161, 915-162, 16-2, 4-3, 13-4, 21-5, 19-6, 26-7, 27-8. MARCH—W-29-9, 56-10, 67-11, 60-12, 70-13, 71-14, 79-15, 85-16, 68-17.

NEW POSITIONS OPEN

SALES representative to contact progressive farmers in Cincinnati trading area of four states, to survey needs, plan and sell sprinkler irrigation systems, and supervise installations. Also sell related items such as aluminum farm gates, roofing, grain bins, and crop driers. College training in agricultural engineering or agriculture desirable but not required if practical experience and general knowledge are satisfactory. Agricultural sales, teaching or farming experience. Pleasant disposition, ability to speak and write, liking for people, contact work, and travel. Opportunity to grow with a small, active organization pioneering in portable irrigation and other sound farming developments. Age 25-50. Salary open, depends on ability and job responsibilities. Compensation is combination of base salary, incentive pay, and travel expenses. O-88-511

EXTENSION AGRICULTURAL ENGINEERS (2), one for work in housing and one in rural electrification. To handle field work with county and home demonstration agents and farm people in a southern state. BS deg in agricultural engineering, MS deg preferred. Extension or similar experience desirable. Farm background and ability to get along with associates. Good opportunity for advancement. Progress entirely up to individual. Age 27-35. Salary $4200-5500 range, 12-mo basis, 30-day vacation. O-87-512

ENGINEERS and junior engineers for design and development in all lines of farm machinery with established manufacturer in the Midwest. Technical agricultural or mechanical engineering degree. Farm background. Some experience in design and development of farm machines. Able to get along with people. Excellent opportunity in fast-growing organization with large development program. Age 22-35. Salary open. O-90-513

ENGINEER, for design and development of farm equipment, to improve established products and create new ones, in small product engineering department with progressive manufacturer of tillage and crop handling equipment in Midwest. BS deg in agricultural or mechanical engineering. Farm background. Drafting room experience 2 yr. Initiative and imagination. Genuine interest in design of farm equipment. Permanent connection. Opportunity commensurate with ability. Age 24-35. Salary open. O-118-514

AGRICULTURAL or mechanical engineers (indefinite number), for design and development work. Northeastern state location. BS deg in agricultural or mechanical engineering, or equivalent qualifying experience. Experience in design and development of corn pickers, corn planters, or tillage tools especially desired. Salary open. O-115-515

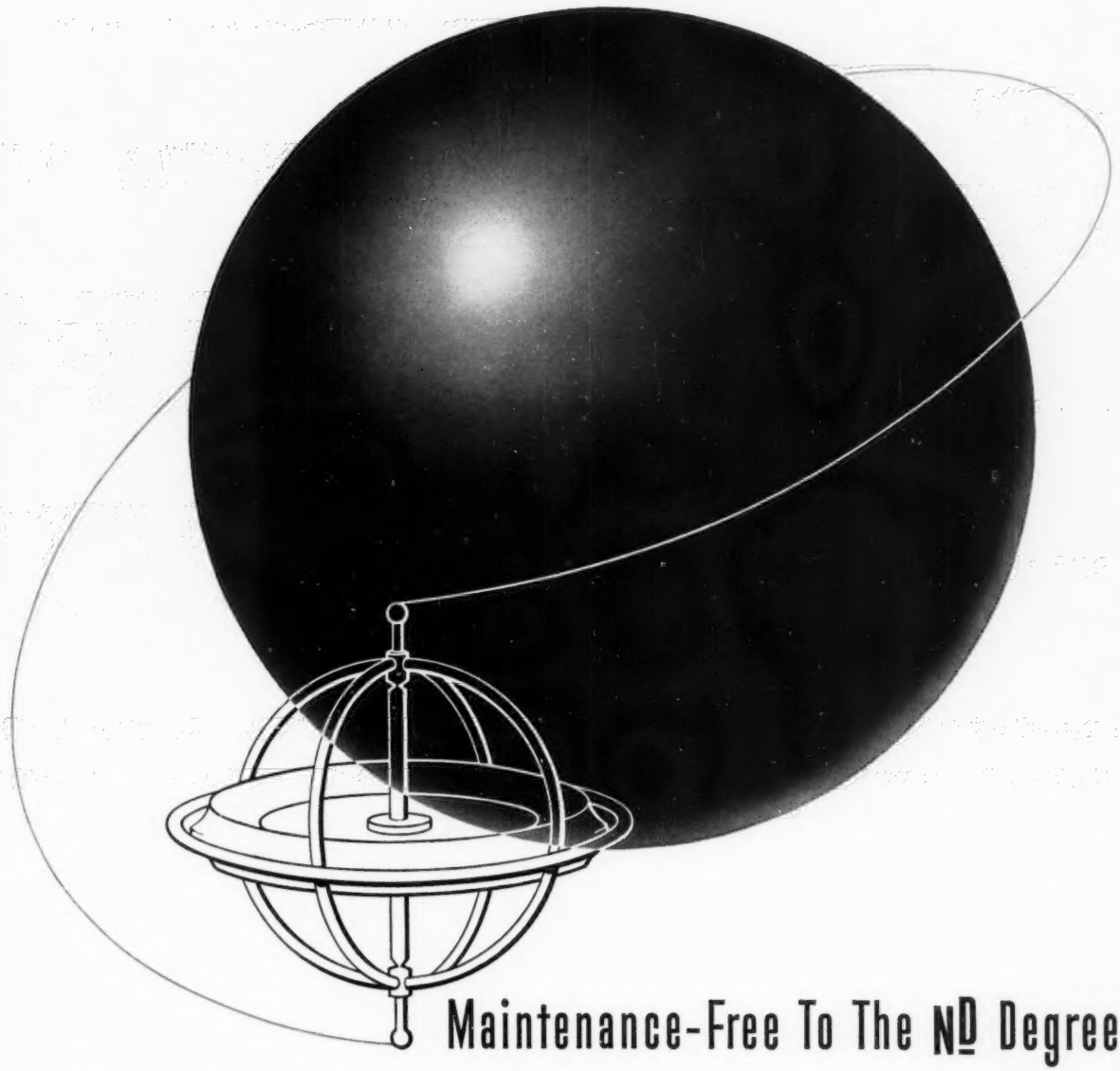
NEW POSITIONS WANTED

DESIGN, development, or research in power and machinery, farm structures or rural electric field, with industry or public service, any location. BS deg in agricultural engineering, 1951, University of Georgia. Farm background. One year with farm equipment dealer. War enlisted and commissioned service in Navy and Air Force 4½ yr, including special instruction in automotive maintenance and electronics. Married. Age 28. No disability. Available on reasonable notice. Salary $3300-3600. W-97-18

DESIGN, development, sales or service in power and machinery, with industry. Any location. Student in agricultural engineering at Cologne, Germany. Expect to graduate in July. Farm apprenticeship and farm machine operation, 2 yr. Single. Age 23. No disability. Available in August, subject to obtaining passport. Salary open. W-64-19

DEVELOPMENT, research, extension, or teaching in irrigation or farm machinery, in Southeast, or East, or Southwest, preferably with opportunity for graduate study. BS deg in civil engineering, 1935, New Mexico State College. Water utilization and irrigation investigations in western U.S., 7 yr. Irrigation and agricultural engineering advisor to foreign governments, 10 yr. Married. Age 43. No disability. Available July 1. Salary open. W-80-20

DESIGN, development, extension, or teaching in soil and water field or that in combination with power and machinery, with public service or manufacturer, any location. BS deg in agricultural engineering, 1944, University of Nebraska. MSAE, 1949; Ph D in agricultural engineering expected 1954, Michigan State College. Nebraska farm background. Instructor in agricultural engineering 4 yr, teaching and research. War enlisted and commissioned service 2½ yr, Army Corps of Engineers, including one year as utilities maintenance officer on Saipan. Married. Age 30. No disability. Available July 1. Salary open. W-134-21



Maintenance-Free To The Nth Degree

From tiny truck farms to wheat acreage that stretches to the horizon . . . from cotton in the South to corn in the Mid-West . . . from strawberries in Maryland to sugar beets in Colorado . . . American farmers are harvesting bigger crops, at lower cost, with the aid of implements equipped with New Departure ball bearings.

The Sealed-for-Life bearings originated by New Departure bring bearing maintenance time down to zero. And they never need adjustment. Other types require lubrication only at long intervals.

For load capacity and long life, for easy installation and low upkeep, New Departures are favored by manufacturers and operators. Keep your eye on the BALL to be sure of your BEARINGS!

NOTHING ROLLS LIKE A BALL

This booklet illustrates many types of mechanisms which are improved by the use of New Departure "Lubricated-for-Life" ball bearings. Send for your free copy today.

NEW DEPARTURE

BALL BEARINGS

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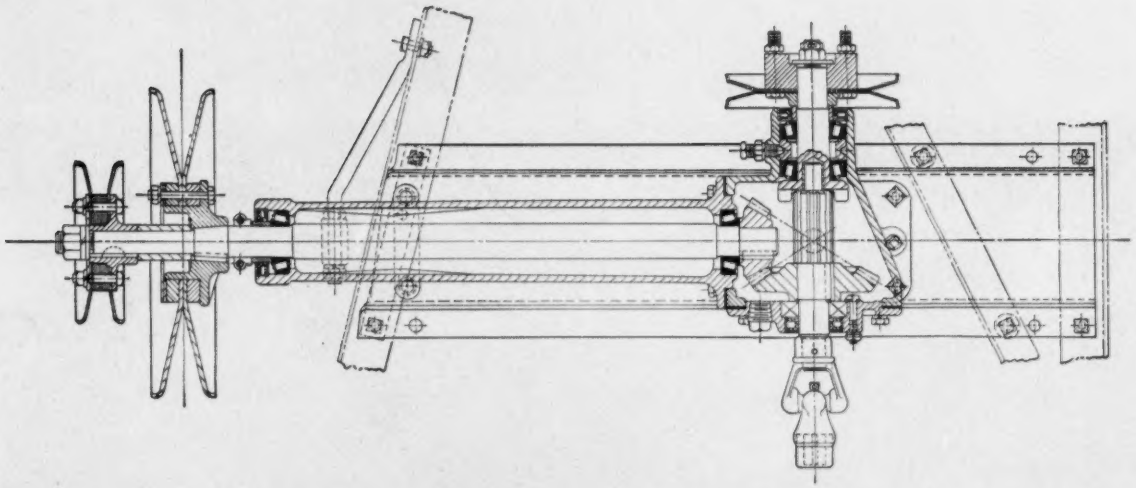
Also Makers of the Famous New Departure Coaster Brake

EVERY NEW FARM TRACTOR HAS TIMKEN BEARINGS; MORE AND MORE IMPLEMENTS ARE USING THEM, TOO!

Timken bearing application in the gear box of ALL-CROP Harvester—another farm machine in which Agricultural Engineers have solved three of their biggest design problems by using Timken bearings. Pinion shaft has indirect tapered bearing mounting. Bevel gear shaft also has indirect tapered bearing mounting adjacent to V-belt drive.



How Allis-Chalmers gets accurate gear mesh in ALL-CROP Harvester gear box

ENGINEERS at Allis-Chalmers set out to get the most accurate gear mesh possible for their ALL-CROP Harvester gear box. Thrust loads from the spiral bevel pinion, plus heavy radial loads, posed tough bearing problems. To take the combined loads and to keep shafts aligned, they specified that the shafts be mounted on Timken® tapered roller bearings.

Because of tapered construction, Timken bearings take both radial and thrust loads in any combination. Line contact between the rollers and races provides extra load-carrying capacity. Shafts are held in proper alignment, gears mesh accurately. A smooth flow of power is assured, wear minimized.

Timken bearings lick a dirt-and-moisture problem, too. They make closures more effective by holding housings and shafts concentric. Dirt and moisture stay out—lubricant stays in.

Timken bearings help implement engineers solve three of their biggest design problems: (1) combination loads, (2) dirt, (3) ease of operation. And Timken bearings assure farmers of longer implement life, less chance of breakdowns, higher towing speeds and less frequent lubrication.

For more information write for your free copy of "Tapered Roller Bearing Practice on Current Farm Machinery Applications", The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

The farmer's assurance of better design

Tapered Roller
TIMKEN BEARING
EQUIPPED

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ◎ AND THRUST →◎← LOADS OR ANY COMBINATION